

SCIENCE

EDITORIAL COMMITTEE : S. NEWCOMB, Mathematics ; R. S. WOODWARD, Mechanics ; E. C. PICKERING, Astronomy ; T. C. MENDENHALL, Physics ; R. H. THURSTON, Engineering ; IRA REMSEN, Chemistry ; JOSEPH LE CONTE, Geology ; W. M. DAVIS, Physiography ; HENRY F. OSBORN, Paleontology ; W. K. BROOKS, C. HART MERRIAM, Zoology ; S. H. SCUDDER, Entomology ; C. E. BESSEY, N. L. BRITTON, Botany ; C. S. MINOT, Embryology, Histology ; H. P. BOWDITCH, Physiology ; J. S. BILLINGS, Hygiene ; WILLIAM H. WELCH, Pathology ; J. McKEEN CATTELL, Psychology ; J. W. POWELL, Anthropology.

FRIDAY, AUGUST 24, 1900.

CONTENTS:

<i>The Mission of Science in Education</i> : PROFESSOR JOHN M. COULTER.....	281
<i>The Zeeman Effect</i> : DR. HERBERT M. REESE...	293
<i>European Apple Tree Canker in America</i> : W. PADDOCK	297
<i>Zoology at the American Association</i> : PROFESSOR C. H. EIGENMANN.....	299
<i>Scientific Books</i> :—	
<i>Bourne's Introduction to the Comparative Anatomy of Animals</i> : PROFESSOR J. S. KINGSLY.	
<i>Professor Mosso's Lectures at the Clark University Decennial</i> : PROFESSOR G. V. N. DEARBORN	311
<i>Scientific Journals and Articles</i>	313
<i>Discussion and Correspondence</i> :—	
<i>Three forgotten names for Birds</i> : WILLIAM J. FOX	314
<i>Notes on Inorganic Chemistry</i> : J. L. H.....	314
<i>The University of Birmingham</i> : PROFESSOR R. H. THURSTON	315
<i>The Prevention of Hail Storms</i>	316
<i>The British Congress on Tuberculosis</i>	316
<i>Scientific Notes and News</i>	317
<i>University and Educational News</i>	320

MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

THE MISSION OF SCIENCE IN EDUCATION.*

THE average graduate from an American university needs no counsel as to his conduct when he comes to face 'the untried world.' He has had his eyes open, and has tried the world more or less, often too much; and has already been surcharged with advice from those of larger experience. If he does not know the elements of success, it is not because he has failed to hear of them; and it only remains for him to receive the teaching which comes from experience. I address these graduates, therefore, with the consciousness that it is too late to add effective advice, and too early to appeal to their experience. I come, therefore, not to youths who are about to be sent away for the first time from the fostering care of a mother, but to university men and women, interested in whatever concerns higher education, and I wish to speak to them of the mission of science in education.

In its broadest sense science includes all knowledge, but the reference here made is to the ordinary application of the word in schemes of education. Perhaps even this needs limitation, if by chance any one has confused reading about science with scientific training; for reference is made to science taught by the laboratory method, which merely means direct and personal contact with the subject matter.

* An address delivered at the annual commencement of the University of Michigan, June 21, 1900.

The advent of science, as thus defined, into schemes of college and university education, was unpromising. It was like one born out of due season, for whom there is no place or preparation. The courses of study were already filled with subjects, all of which naturally seemed to be far more important than the interloper, who had to be content for a time with the crumbs which fell from the already crowded table. Scraps of time and information rather than training was not a happy combination to develop an educational result from any subject, and least of all from science. The general attitude at first towards the laboratory method is well illustrated by the experience of Rafinesque, the first teacher west of the Alleghanies who attempted to introduce it. From 1823 to 1826 he was professor of modern languages and the natural sciences in Transylvania University, in Lexington, Kentucky. In his botanical instruction he ventured to bring plants into the recitation room, which was objected to by the Faculty as 'tending to produce disorder among the students, and to convert a serious recitation into the mere examination of curiosities, thus wasting valuable time.'

After science had secured a definite place in the colleges and was making its first feeble attempts at laboratory work, it was confronted by an obstacle more serious than scraps of time, an obstacle which still exists in certain quarters, either in fact or in spirit. Instead of being admitted to equal rights in a republic of subjects, it was degraded by the organization of so-called scientific courses, which were confessedly inferior to the others; and as if to insure a weak result the scientific course was often made shorter than the others. In my own college, but a type of the great majority of colleges in those days, a student who was not strong enough to graduate in four years in the classical course could graduate in three years in the scientific course. No

self-respecting student could afford to be a 'scientific' under such conditions, so that only the weaklings, with three-fourths of the legitimate time at their command, became the exponents of the advantages of scientific training! All those who are middle-aged can testify to a similar college experience, and the result was a deep-seated distrust of the value of science in education, an honest contempt for its results, which distrust and contempt have been handed down to the children now in college, so far as they are being influenced by parental advice. This result is natural, and I have no word of blame for those who possess the feeling, but the conditions which developed it were simply inexcusable.

In spite of the unfortunate conditions which accompanied the advent and much of the history of science in education, it has now become firmly established, has a reasonable rank and allotment of time, and is in a position to show what it has done and what it can do for education. Time enough has not yet elapsed, and absolute equality has not yet been sufficiently attained to permit the fullest expression of legitimate results, but in some degree and at some universities the results are beginning to be apparent. It is hard for one to appreciate 'the mighty power of what has been over the frail form of what might be,' so that sentiment as yet unconsciously influences the judgment even of the fair-minded. But certain results of the presence of science in education seem to be evident enough, and a few of these I propose to present in the form of definite propositions.

1. *Science has revolutionized educational methods.*—This proposition needs no special defence, as it seems to be well nigh universally admitted. In fact, it is the pride of almost every subject to-day that it is taught by the laboratory method. This simply means that the old recitation, which was the retailing of second-hand informa-

tion as to facts, and of second-hand opinions concerning them, has given place to the direct observation of facts and the expression of individual opinion concerning their significance. As a result, students are sought to be made thinking rather than memorizing machines, with the initiative power developed rather than the imitative.

Even in the study of literature, the very stronghold of the cult organized by the humanities, the books about literature have been banished, and the contact is with literature itself. The legitimate offspring of the laboratory is the seminar, and even in the most elementary work the laboratory idea of presentation prevails. In short, the introduction of the laboratory started the movement which has resulted in more rational methods of teaching in every department of college activity. It was my good fortune to be a member of the college association of a neighboring State during the whole period of this evolution of methods, and it well exemplified the three successive attitudes of mind which Agassiz said were always apparent when a new and somewhat startling conclusion of science was announced. At first people say it is not true; later it is contrary to religion; and last everyone knew it before. So in the later stages of my experience I have been interested in hearing that every real teacher uses the laboratory method, and that science has no special claim upon it. And this is true in the sense that its claim is now merely a historic one. Every result which comes merely from the method may be duplicated by non-scientific subjects, for teaching in general has become scientific. The present and future value of science in education, therefore, cannot come from its peculiar methods, but from something inherent in the subject itself. I am glad to make this statement emphatic, for it is often said that the mission of science in education is to teach the laboratory method.

Incidentally it did fulfill this mission, but if that were all it could now be banished without weakening our schemes of education.

1. *It develops the scientific spirit.*—By the scientific spirit I mean a certain attitude of mind. What this attitude is may be indicated by noting some of its characteristics.

(1) *It is a spirit of inquiry.*—In our experience we encounter a vast body of established belief in reference to all important subjects, such as society, government, education, religion, etc. It is well if our encounter be only objective, for it is generally true, and a more dangerous fact, that we find ourselves cherishing a large body of belief, often called hereditary, but really the result of early association. Nothing seems more evident than that all this established belief which we encounter belongs to two categories: (1) the priceless result of generations of experience, and (2) heirloom rubbish. Unfortunately, the discovery of the latter has often resulted in weakening the hold of the former. The young inquirer, or the non-logical inquirer is in danger of condemning all the conclusions of the past when one is found wanting. Towards this whole body of established belief the scientific attitude of mind is one of unprejudiced inquiry. It is not the spirit of iconoclasm, as some would believe; but an examination of the foundations of belief. The spirit which resents inquiry into any belief, however cherished, is the narrow spirit of dogmatism; and is as far removed from the true scientific attitude as the shallow-minded rejection of all established beliefs. The childhood of the race accumulated much which its manhood is compelled to lay aside, and the world needs a thorough going over of its stock in trade. Such work cannot be done all at once, or once for all, for it must be a gradual sloughing off as the spirit of inquiry becomes more generally diffused. It must become

evident that this spirit is diametrically opposed to intolerance, and that it can find no common ground with those who confidently and sometimes violently affirm that the present organization of society is as good as it can be ; that the present republics of the world represent the highest possible expression of man in reference to government ; that the past has discovered all that is best in education ; that the mission of religion is to conserve the past rather than to grow into the future. This is not the spirit of unrest, of discomfort, but the evidence of a mind whose every avenue is open to the approach of truth from every direction. Like the tree, it is rooted and grounded in all the eternal truths that the past has revealed, but is stretching out its branches and ever renewed foliage to the air and the sunshine, and taking into its life the forces of to-day.

Dogmatism still finds numerous victims, for education has not yet touched the majority, but everyday the possible victims are becoming fewer in number, and those who seek to lead opinion must presently abandon the method of bare assertion. The factors in this general intellectual progress are perhaps too subtle and interwoven to analyze with certainty, but conspicuous among them is certainly the development of scientific training.

For fear of being misunderstood, I hasten to say that this beneficent result of scientific training does not come to all those who cultivate it, any more than is the Christ-like character developed in all those who profess Christianity. I regret to say that even some who bear great names in science have been as dogmatic as the most rampant theologian. But the dogmatic scientist and theologian are not to be taken as examples of 'the peaceable fruits of righteousness,' for the general ameliorating influence of religion and of science are none the less apparent. It is not the speech of the con-

spicuous few that is thus leavening the lump of human thought, but the quiet work of thousands of teachers.

(2) *The scientific spirit demands that there shall be no hiatus between an effect and its claimed cause, and that the cause claimed shall be adequate.*—It is in the laboratory that one first really appreciates how many factors must be taken into the count in considering any result, and what an element of uncertainty an unknown factor introduces. In the very simplest cases, where we have approximated certainty in the manipulation of factors to produce results, there is still lurking an element of chance, which simply means an unknown and hence uncontrolled factor. Even when the factors are well in hand, and we can combine them with reasonable certainty that the result will appear, we may be entirely wrong in our conclusion as to what in the combination has produced the result.

For example, we have been changing the forms of certain plants at will, by supplying in their nutrition varying combinations of certain substances. By manipulating the proportions of these substances we produce the expected results. It was perhaps natural to conclude that the chemical structure of these particular substances produces the result, and our prescription was narrowed to certain substances. Now, however, it is discovered that the results are not due to the chemical nature of the substances, but to a peculiar physical condition which is developed by their combination, a condition which may be developed by the combination of other substances as well ; so that our prescription is much enlarged. In this operation we are thus freed from slavery to particular substances, and must look only to the development of a particular physical condition. It seems to me that there is a broad application here. In education, we are in danger of slavery to subjects. Having observed

that certain ones may be used to produce certain results, we prescribe them as essential to the process, without taking into account the possibility that other subjects may produce similar results.

In religion, we are in danger of formulating some specific line of conduct as essential to the result, and of condemning those who do not adhere to it. This is the essence of formalism, and its logical outcome, unchecked by common sense, is illustrated by the final expression of Jewish temple worship.

That there may be many lines of approach to a given result, if that result be a general condition, is a hard lesson for mankind to learn.

If it is so difficult to get at the real factors of a simple result in the laboratory, and still more difficult to interpret the significance of factors when found, in what condition must we be in reference to the immensely more difficult and subtle problems which confront us in social organization, government, education, and religion, especially when it is added that the vast majority of those who have offered answers to these problems have had no conception of the difficulties involved in reaching absolute truth. It is evident that in the vast problems which concern human welfare in general we are but groping our way, and that our answers as yet are largely empirical. The proper effect of such knowledge is not despair, but a receptive mind. In my judgment, therefore, the diffusion of the scientific spirit will make it more and more difficult for any one with a *nostrum* to get a hearing.

The prevailing belief among the untrained is that any result may be explained by some single factor operating as a cause. They seem to have no conception of the fact that the cause of every result is made up of a combination of interacting factors, often in numbers and combinations that are abso-

lutely bewildering to contemplate. An enthusiast discovers some one thing which he regards and perhaps all unprejudiced and right-thinking people regard as an evil in society or in government, and straightway this explains for him the whole of our present unhappy condition. This particular tare must be rooted up, and rooted up immediately, without any thought as to the possible destruction of the plants we must cultivate. The abnormal tissue must be destroyed without reference to the fact that the method of destruction may debilitate the normal tissue.

This habit of considering but one factor, when perhaps scores are involved, indicates a very primitive and untrained condition of mind. In the youth of science it often threw its votaries into hostile camps, each proclaiming rival factors; when the problem really demands all the factors they all had and many more besides.

It is fortunate when the leaders of public sentiment have got hold of one real factor. They may overdo it, and work damage by insisting upon some special form of action on account of it, but so far as it goes it is truth. It is more apt to be the case, however, that the factor claimed holds no relation whatsoever to the result. This is where political demagoguery gets in its most unrighteous work, and preys upon the gullibility of the untrained, and is the soil in which the noxious weeds of destructive socialism, charlatanism, and religious cant flourish.

It is needless for me to enlarge the horizon of illustration, by including numerous fields of human thought and activity, for your own thought outruns my statement, and recognizes the conditions in every direction. It is to such blindness that scientific training is slowly bringing a little glimmer of light, and when the world one day really opens its eyes, and it is well if it opens them gradually, the old things will have passed away.

(3) *The scientific spirit keeps one close to the facts.*—One of the hardest things in my teaching experience has been to check the tendency of many students to use one fact as a starting point for a flight of fancy which is simply prodigious. Such a tendency is corrected of course when facts accumulate somewhat, and flight in one direction is checked by a pull in some other direction. But most of us have the tendency, and the majority are so unhampered by facts that flight is free. This exercise is beautiful and invigorating if it is recognized to be just what it is, a flight of fancy; but if it results in a system of belief it is a deception. There seems to be abroad a notion that one may start with a single well-attested fact, and by some logical machinery construct an elaborate system and reach an authentic conclusion, much as the world has imagined for more than a century that Cuvier could do if a single bone were furnished him. The result is bad, even though the fact have an unclouded title. But it too often happens that great superstructures have been reared upon a fact which is claimed rather than demonstrated.

We are not called upon to construct a theory of the universe even upon every well-attested fact, and the sooner this is learned the more time will be saved and the more functional will the observing powers remain. Facts are like stepping stones; so long as one can get a reasonably close series of them he can make some progress in a given direction, but when he steps beyond them he flounders. As one travels away from a fact its significance in any conclusion becomes more and more attenuated, until presently the vanishing point is reached, like the rays of light from a candle. A fact is really only influential in its own immediate vicinity; but the whole structure of many a system lies in the region beyond the vanishing point.

We must wonder what lies beyond, we

must try our wings in an excursion now and then, but very much stress must never be laid upon the value of the results thus obtained.

Such ‘vain imaginings’ are delightfully seductive to many people, whose life and conduct are even shaped by them. I have been amazed at the large development of this phase of emotional insanity, commonly masquerading under the name of subtle thinking. Perhaps the name is expressive enough, if it means thinking without any material for thought. And is not this one great danger of our educational system, when special stress is laid upon training? There is danger of setting to work a mental machine without giving it suitable material upon which it may operate, and it reacts upon itself, resulting in a sort of mental chaos. An active mind turned in upon itself, without any valuable objective material, can certainly never reach any very reliable results.

It may not be that the laboratory in education is the only agency, apart from common sense, which is correcting this tendency: but it certainly teaches most impressively, by object lessons which are concrete and hence easiest to grasp, that it is dangerous to stray away very far from the facts, and that the further one strays away the more dangerous it becomes, and almost inevitably leads to self-deception.

There is no occasion for a further analysis of the scientific spirit or attitude of mind. It could be followed out into various ramifications of greater or less importance, but enough has been said to indicate its tendency. Nor is any further claim made at this point than for the laboratory method, for the scientific spirit is now being developed by subjects which are not grouped among the sciences as defined in this paper. It simply follows from the laboratory method, but as this came in by way of the sciences, and is still of easiest

and most direct application in connection with them ; so the characteristics of the scientific spirit indicated above are more easily and effectively developed in contact with the peculiar materials of science.

But I have still stronger claim to make for science as an essential constituent of all education, and that is

2. It gives a training peculiar to itself, and one that is essential in every well-balanced education.—The real educational significance of the training in laboratories devoted to science is very commonly overlooked, both by those who know nothing about it from personal experience, and even by those who are teachers of science. Many learn to go through the motions without appreciating the substratum of educational philosophy. Moreover, the knowledge of the educational significance of this special form of training has been slowly developed as the results have appeared.

Perhaps the earliest, and of course the most superficial form of statement explaining the purpose of scientific study was that it teaches the laboratory method. The inference was that the sciences are of no particular educational advantage in themselves, but are merely useful in teaching a valuable method. In so far as this emphasized the fact that reading or reciting about science cannot be regarded as training in science, and in so far as it recognized that science is to be credited with introducing a revolutionary and invaluable educational method, the statement is true enough; but to regard these purely incidental results as being in any sense the end of scientific training is far enough from the mark. The laboratory method holds no more relation to science than do algebraic symbols to algebra ; they both merely represent useful machinery for getting at the real results. And further, as has been shown, if the teaching of a method is the only function of science in education, when this method

has been learned and has become universally applied, the mission of science in education is at an end.

Another commonly stated advantage of training in science is that it cultivates the power and habit of observation. This is certainly true, but with equal certainty this result is not peculiar to scientific training, for it belongs to the laboratory method, and appears whenever the method is applied to any subject. It may be claimed that the most direct and tangible materials for observation fall within the province of science, but this is a difference of degree rather than of kind, and therefore the result may be obtained apart from science. It is true that in the elementary stretches of education the methods are still prevailingly conventional, and therefore, stunt the natural powers of observation. The fine tentacles of inquiry which are put out in every direction by the child thus become atrophied, so that when later in his educational experience he is introduced into the laboratory he is as helpless as though transferred to a totally different set of life conditions. It takes almost a surgical operation to open his eyes, and he is apt to have lost not only the power but with it also the desire of observation. This wholesale and criminal mutilation of natural powers, however, is not the fault of the subjects studied, but of the conventional methods employed, which demand faith rather than sight, memory rather than reason, the sacrifice of truth to conventional ideas. To keep these important powers functional may still be an important mission of science in elementary education, but when the conventional method has been replaced by the natural in all subjects of study, this mission also will have been fulfilled, and will be recognized merely as an incident in scientific training.

Those who are accustomed to look a little beneath the surface before formulating a statement are very apt to be content with

saying that the study of science trains in the power of analysis. This is certainly getting the subject upon higher ground, and suggests a result which is worthy of every effort. The power of analysis is one of immense practical importance, and the value of its cultivation will not be denied. To imagine, however, that analysis is the ultimate purpose of science, is not to go very much farther than to say that the ultimate purpose is the laboratory method. The latter is the method, the former is but the first step in its application. But even this step is by no means peculiar to science, for it is the initial one in the teaching of every subject. In our search, therefore, for the peculiar benefits of science in education, we are again compelled to look further.

Beyond analysis lies synthesis, and this certainly represents the ultimate purpose of science. The results of analysis are as barren as a bank of sand until synthesis lays hold of them. It is just here that a large amount of science teaching fails, for to many teachers the accumulation of unrelated facts seems to be the end of scientific study, and the results of the laboratory may be represented by a chaotic pile of brick rather than some definite structure dominated by an idea. Almost anyone may accumulate facts, but to relate them, to distinguish the significant and the insignificant, to recognize that they are merely external expressions of something general, belongs to the highest stretches of scientific training. May I be permitted to say, without being misunderstood, that the potent influence of the German laboratories upon American establishments has resulted in general in making our best investigators and our worst teachers. The influence is beneficent to the last degree in so far as it lays hold of a disposition to careless work and hasty generalization and holds it down to the patient collection of facts and their very cautious collection; but when it re-

sults in mere Gradgrind teaching all inspiration has evaporated, and the laboratory touches no more the finer mental powers than does a factory. The difference indicated finds its illustration in some of our best known texts, which are merely expressions of styles of teaching. In the one case the facts are presented in the helter-skelter fashion, solid and substantial enough, but a regular mob, with no logical arrangement, no evolution of a controlling idea. Details are endless, no emphasis brings out certain things into prominence and subordinates others, and the whole subject is as featureless as a plain, where the dead level of monotony kills off every one but the drudge. It is the spirit of analysis, a dead body of facts without a vitalizing spirit. In the other case fewer facts are presented, but they are the important ones, and marshaled in orderly array, battalion by battalion, they move as a great whole towards some definite object. The facts may fade away, even the battalions may grow dim, but the great movement remains definite and clear as a memory which is an inspiration. Instead of a level plain, there are mountain peaks and valleys, there is a perspective and there are vistas from every point of view. This is the spirit of synthesis, which vitalizes the great body of facts and makes them glow. To the teacher, in his work of training, an unrelated fact is worse than useless.

But even synthesis is not peculiar to science. To pass by the incidental and temporary and reach the real and permanent contribution of science to education is to discover that it lies not in teaching the laboratory method, in developing the power of observation, in cultivating the spirit of analysis, or even in carrying one to the heights of synthesis; but in the mental attitude demanded in reaching the synthesis. In this regard the demands of science are diametrically opposed to those of the hu-

manities, for instance, using this loose term to express the great region of literature and its allies. The humanities have been and must continue to be a noble course of intellectual development, without which an education is certainly incomplete. It is the most ancient and best known form of culture, and being ancient and bound up with the intellectual development of mankind it must necessarily continue to hold high rank. The general effect of the humanities in a scheme of education may be summed up in a single word *appreciation*. They seek so to relate the student to what has been said or done by mankind, that his critical sense may be developed, and that he may recognize what is best in human thought and action. To recognize what is best involves a standard of comparison. In most cases this standard is derived and conventional; in rare cases it is original and individual; in no case is it founded in the essential nature of things, in absolute truth, for it is apt to shift. In any case the student injects himself into the subject; and the amount he gets out of it is measured by the amount of himself he puts into it. It is the artistic, the aesthetic, which predominates, not the absolute. It is all comparative rather than actual. The ability to read between the lines is certainly the injection of self into the subject-matter, and the whole process may be regarded as one of *self-injection* in order to reach the power of *appreciation*. My claim is that any education which stops with this result is an incomplete one, and that there is another mental attitude which is a necessary complement before a full-rounded education can be claimed; and that this complementary mental attitude is developed by a proper study of the sciences. If the study of nature is conducted so as to cultivate merely a sentimental appreciation of natural objects, it does not fall within the category I am considering, and can in no

way be considered as a study which acts as a complement to the humanities. It is merely more of the same thing. If the proper intellectual result of the humanities is *appreciation*, whose processes demand *self-injection*, the proper and distinctive intellectual result of the sciences is a *formula*, to obtain which there must be rigid *self-elimination*. Any injection of self into a scientific synthesis vitiates the result. The standard is not a variable, an artificial one, developed from the varying tastes of man, but absolute, founded upon eternal truth.

Two such distinct mental attitudes as self-injection and self-elimination must receive attention in education, which cannot be complete without both. They are not contradictory, but complementary, and it takes both to make the 'all-round' man. The exclusive cultivation of either one must result in a lop-sided development. Persistent self-injection tends to mysticism, a confusion of ideals or even vagaries with realities, a prolific cause of all irrational beliefs. Persistent self-elimination narrows the vision to a horizon touched by the senses and clips the wings that would carry us now and then beyond the treadmill of life into a freer air and a wider outlook.

The one needs the other as a check. In their combination self-injection is held back from dangerous flights by the demand to feel something solid beneath the feet; and self-elimination is compelled to raise its eyes now and then from the ground and sweep the heavens.

In our analysis, however, we strip off the flesh and lay bare the skeleton, and are apt to lose sight of the fact that the contour is a composite result. Although the skeletons of the humanities and of the sciences may differ from each other in the fundamental way described, I cannot conceive of the resulting contour of the one as distinct from combination with the other. The self-eliminating result of science must be asso-

ciated with the self-injecting result of the humanities, even though science alone be studied; and the power of appreciation developed by the humanities must always be tempered by the scientific spirit. And yet, the two processes and the two results are so distinct and so complementary that any scheme of education which does not provide for the definite cultivation of these two mental attitudes, and which leaves the complementary part merely to the chances of methods of teaching and mental structure, is in constant danger of resulting in mental distortion.

I have indicated in this very general way the broad principles involved in the mission of science in education. Numerous details might be presented which would justify the claims that have been made, and perhaps such details would have made my thesis more clear, and would have left me in less danger of being misunderstood; but neither the time nor the occasion will permit them.

There is a factor of such overwhelming importance in the effectiveness of the mission of science in education that I cannot forbear the mention of it, and that is the teacher. I have presented the possible, the ideal results, but they can be approximated only by the thoroughly competent teacher. The problem of the teaching of science in the universities is becoming a serious one. There is no need to include in this discussion the teaching of science in the schools, for those engaged in it are devoting their whole time and knowledge to its development. It is sadly true that as a rule they need more time and far more knowledge, but this need is being gradually met, and every year the teaching in the schools is becoming better. On the contrary, I am tempted to say that every year the teaching of science in the universities is becoming worse. Perhaps the statement is too strong, but it expresses a tendency, that must be checked. The university instructor is con-

fronted by two serious duties; he is to instruct, and he is to produce. In the constitution of American universities the primary function of the instructor is to instruct; and, if time and strength permit, the secondary function is to produce. From the theoretical standpoint production is essential to a thoroughly good university instructor, for production makes all the difference between a pump and a perennial spring. There is no special inspiration in the continual retailing of second-hand information. Practically, however, the conscientious teacher must expend all his energy, or at least all his effective energy upon teaching and faculty duties. The logical outcome is that teachers who wish to investigate cease to be conscientious as teachers. Production becomes the principal thing, and instruction a mere incident. It might be expected that these unconscious teachers would be gradually eliminated, but there are two facts which not only prevent the elimination but increase the evil. The first is that in large universities the tenure of office is practically unlimited, and if the instructor is making a name through production his tenure of office is not likely to be terminated, however bad his teaching. The second fact is that in the appointment of new instructors the universities to-day are looking more for productive power than for teaching power. This latter fact reacts seriously upon those who are preparing for university positions, and their whole training is upon problems connected with their subject, to the entire exclusion of those connected with its presentation. In short, my claim is that in the universities our instructors have been trained to investigate rather than to teach. I have never met such wretched teaching anywhere as is daily permitted in the greatest universities. Under such conditions the instructor for a few years makes a spasmodic effort to teach, presently loses his interest in it, and gradually lapses into indifference.

It is a common statement that large universities are no places for undergraduates, as they are turned over to the younger instructors and do not meet the heads of departments. Theoretically this is a serious charge, but practically it is a wise arrangement, for in general it is true that the undergraduate would do well to beware of the old instructor, unless it is his wish to be neglected. The instructor who is a novitiate will work hard for him, even to the point of drudgery, even if he does not always work effectively.

I must not be misunderstood. Those who are born to teach will always teach when placed before a class, and every university has its share of such teachers, and the older they get, the more effective do they become; but I think I am right in claiming that the majority of instructors who have been brought into the universities within the last decade or two are teaching as an incident to investigation. I am not blaming these instructors, for I enter into their feelings most sympathetically. I am merely stating a problem which must be solved. We must have production or teaching will become a treadmill and real universities will have no reason for existence; but we must also have effective teaching. The problem is, how can we have both? The answer is simple, but hard of application, for it involves the natural limitations of men, which they are slow to recognize. Some are born to teach and some are born to produce, and these two classes should be recognized and utilized by the University, but self-recognition is more difficult. As it is, every instructor feels upon himself a pressure to produce, for it is in the atmosphere to-day; but in the majority of cases yielding to this pressure involves a waste of valuable time and energy without any adequate result. Such instructors are unwilling to acknowledge, even to themselves, that they have not

the initiative for profitable investigation, whatever may have been their preparation.

On the other hand, the born investigator is nearly as slow to recognize that he is probably not a successful teacher. With born teachers trying to investigate, and born investigators trying to teach, and still others born to do neither, the average university becomes a good illustration of misdirected energy. If in any way the lines could be drawn so that the two classes could be recognized by themselves, as they already are by their associates, the problem would be solved.

In my judgment it would be fatal absolutely to restrict either to his own field, for the teacher, in his own interest rather than that of his subject, must produce enough to retain and develop his inspiration, and to appreciate the methods and results of investigation; while the investigator, in his own interest rather than that of his students, must teach enough to retain his breadth of vision and to cultivate the power of clear and apt expression.

In connection with any claim for the great and peculiar contributions of science to education, it seems pertinent to refer to a complaint heard now and then that the encroachment of science upon university attention has changed the atmosphere from one that is literary to one that is commercial. A common phrase is: 'the commercializing tendency of modern education.' The idea seems to be that a certain fine flavor of thought and expression is becoming less evident, and that the somewhat indefinite but soaring balloon is being replaced by the locomotive. Without calling attention to the fact that if one wants to get anywhere at any definite time the locomotive is more effective than the balloon, and without inquiring into the personal training or idiosyncrasies of those who make the complaint, I wish to call atten-

tion to a probable explanation of the imaginary change.

The old education, which is reputed to have had such beneficent results, was a magnificent training; but it must never be forgotten that it was an example of extreme specialization. A narrow round of subjects was continually studied and all that can be claimed for specialization appeared in the result. Like all specialization, however, its effective application depended upon the mental aptitude of the student. As these aptitudes are quite varied, the old specialized education selected from the mass the few to whom it was adapted, and these became really educated and dominated the university atmosphere, their more numerous fellows falling out unnoticed in the unequal race. And so the flavor which belongs to this special kind of education became the universal flavor of the educated.

When new subjects appeared, and courses began to be multiplied, other students began to be selected from the mass and joined the society of the educated, and the old flavor ceased to be one peculiar to education in general.

The change, therefore, is simply that more students than formerly are reaching what may be called an education, and the difference is one of proportion, not of actual number. Opportunity for the old education is still with us, and those who are adapted still take advantage of it, and their number is greater than ever before. But they are compelled to acknowledge as brothers in the fraternity of the educated a host who had been excluded before through lack of opportunity. There is no longer an aristocracy in education, and the democracy of to-day demands that all who are trained, by whatever method, shall strike hands as brothers and equals.

In conclusion, may I be permitted to say that the full significance of scientific training will appear only when it begins in some

form in the primary schools and touches the student at every stage of progress. Appealing as it does to the most natural tendencies of childhood, its greeting at the threshold of school experience is that of the one familiar friend, whose presence relates the young to things which they can see and handle, and saves them from that desolation of spirit and mental warping which comes from exclusive contact with the conventional and the intangible. The university owes a great service to the schools in this particular, and the tentacles of its influence must constantly be reaching delicately and inquiringly into school instruction. What the schools can do or cannot do, what they should do or should not do, are questions which cannot be answered in *ex cathedra* fashion. The wilful ignorance of many university instructors in reference to the work of schools upon which they depend is amazing. The university as a whole recognizes and encourages the intimate relationship, but only an instructor here and there interests himself in discovering the real situation. The result of this appears usually in requirements for admission, which are often adapted to some theoretical university position rather than to the possibilities of the modern American high school. In the debates upon these admission requirements a large faculty is apt to be divided, and the line of division usually separates those who know the schools from those who do not. If the latter be in the majority, the university is at once effectively handicapped. There is much talk of forcing schools to university standards, but this forcing is necessarily artificial and temporary if it runs counter to the inevitable tendencies which one who knows recognizes in the American school system. This system is more impregnable than the universities, for it is more extensive and better adapted to the peculiar conditions of American civilization. It is only

a question of time when every university will recognize the fact that it must adapt itself to the possibilities of the schools, and that ancient or artificial standards can be maintained only so long as they approve themselves to the experience of the schoolmaster. The mountain will never come to Mahomet. To compel schools to differentiate early a small and select and expensive class for entrance to the universities is unfair both to school and to the university, and seriously checks the diffusion of higher education. To deny the privilege of breathing the university atmosphere to any product of a good secondary school involves such a narrow conception of education that one dislikes to associate it with the university. It has always seemed an anomaly that universities are inclined to rate themselves more upon the basis of their raw material than their finished product. A fine-meshed screen is set up at the beginning of the university career, when it would seem far more logical to set it up at the other end. This matter of entrance has much to do with the opportunity given to science to express itself in education. If its most promising and best trained material is turned back or handicapped when attempting to enter the university, a certain kind of educational theory may command the result, but it is a blockade against the general progress of education, in so far as it cuts off a great agency from operating upon the legitimate material.

A statement summarizing the claims set forth in this paper may be formulated as follows: The introduction of science among the subjects used in education has revolutionized the methods of teaching, and all subjects have felt the impulse of a new life; it has developed the scientific spirit, which prompts to investigation, which demands that belief shall rest upon a foundation of adequate demonstration, which recognizes that the sphere of influence sur-

rounding facts may be speedily traversed and that everything beyond is as uncertain as if there were no facts; it has introduced a training peculiar to itself, in that it teaches the attitude of self-elimination, an attitude necessary in order to reach ultimate truth, and thus supplements and steadies the other half of life, which is to appreciate. To obtain these results, there must be teachers who can teach, whose background and source of supply is the investigator. Moreover, the results are immensely desirable, inasmuch as they do not interfere with anything that is fine and uplifting in the old education, but simply mean that the possibilities of high attainment and high usefulness are open to a far greater number.

JOHN M. COULTER.

THE ZEEMAN EFFECT.

EARLY in the year 1897 a paper was published in several journals by Dr. P. Zeeman, describing a series of experiments to determine the effect of magnetism upon the spectrum of a source of light placed in the magnetic field. The electromagnetic theory of light indicated in a general way that there would probably be some effect, and several investigators had already sought for it without success. The most noteworthy of these was Faraday, who made it the object of one of his last researches, and in this country Rowland made an examination with a Rutherford grating, before he had himself begun to rule the more perfect gratings of the present day. Zeeman himself had made an earlier unsuccessful attempt, and Fizeau really observed what may have been the same phenomenon which Zeeman finally discovered, but he failed to understand its true character.

With the aid of a strong magnet and better spectroscopic apparatus than any of his predecessors had used, Zeeman attacked the problem the second time with success. He placed a Bunsen flame containing com-

mon salt between the poles of the electromagnet and focused the light on the slit of his spectrometer, arranging the flame so that the D-lines were sharply defined. As soon as the magnet was excited both lines widened out very much. By a careful series of subsidiary experiments he showed that the widening was due directly to the action of the field and was not a secondary effect such as might be caused by changes of density in the flame.

These results were communicated before publication to Professor Lorentz, who showed Dr. Zeeman that the widening could be predicted from Lorentz's theory that light is generated by the vibrations of electrically charged particles or ions; and that the same theory indicated that the edges of the widened lines should be plane-polarized or circularly-polarized according as the light falling upon the slit came from the source in a direction perpendicular or parallel to the lines of magnetic force, and that the amount of the widening would give the ratio of the charge to the mass of the luminous particles. Zeeman was able to verify fully the predictions as to polarization, and deduced from Lorentz's equations, as a rough value for the ratio e/m , the value 10^7 .

The substance of the reasoning which led Lorentz to his conclusions is this: the motion of any ion can be resolved into a rectilinear component along the lines of force and two circular components in opposite senses in a plane normal to the same lines. These moving charges constitute currents, and consequently there are electromagnetic forces acting on the particles carrying the charges, owing to the presence of the magnetic field. The component along the lines of force is unaffected, while one of the circular components is accelerated and the other retarded by an equal amount. Hence we have present three distinct vibrations: one linear, along the lines

of force, with the same period as the undisturbed motion; and two circular, in opposite senses, having periods, one a little longer and the other a little shorter than the original. Hence if the difference of periods introduced is sufficient to resolve the three lines in the spectrometer, and the light falling upon the slit comes from the source in a direction parallel to the lines of force, two lines instead of one will appear in the spectrum, one composed of right-handed and the other of left-handed polarized light; for the linear vibration can send no wave in its own direction. On the other hand, if the light proceeds directly across the lines of force to the slit, a triplet will be seen, consisting of a central component polarized in a plane normal to the lines of force and two lateral components polarized in a plane through the lines of force (bearing in mind that on the electromagnetic theory of light the direction of electric force is normal to the plane of polarization). But, if the difference of period is smaller, the lines of the doublet in the one case and of the triplet in the other, being streaks of finite width and not lines in the mathematical sense, will overlap, forming a single widened line whose edges alone show any definite polarization. Lorentz's mathematical treatment, which we will omit here, leads to the expression

$$\frac{\Delta\lambda}{\lambda^2} = \frac{e}{m} \cdot \frac{H}{2\pi V},$$

where λ is the wave-length of the original line, $\Delta\lambda$ is the difference in wave-length introduced between the extreme components of the triplet by the external magnetic force H , e is the charge on the moving ion, m its mass, and V the velocity of light.

It follows from this that if e/m is the same for all the luminous ions which give the spectrum of any one substance, the separation $\Delta\lambda$ is proportional to the square of the wave-length; but it became evident

as soon as the experimental study was extended that no such general law could be laid down. For the same region in the spectrum of an element the separation may vary from apparently nothing up to an Angström unit or more for a moderately intense field.

The high value of e/m indicated by this phenomenon is significant. It is of about the same order as that found for the cathode ray particles and the ions caused by uranium and Röntgen rays and ultraviolet light; but the value for electrolytic ions is only about 400.

Zeeman's experiments were soon repeated by other investigators, including Lodge, Michelson, Preston and Cornu; and it was not long before magnetic fields were used of strength sufficient to fully resolve the several components. It then became known that the phenomenon was not nearly so simple as the first observations would indicate. Lodge* first noticed indications of a quadruplet in the case of the D -lines instead of a triplet, and later Preston† and Cornu‡ observed unmistakable quadruplets both in the case of D_1 and in the spectra of cadmium and magnesium. A little later Becquerel and Deslandres§ discovered in the iron spectrum a new type of triplet in which the states of polarization of the inner and outer components were interchanged. In February, 1898, Michelson published in the *Astrophysical Journal* a paper giving results obtained with the interferometer, some of which are not in accord with those obtained before and since then with the grating. Among other things he said that all lines are divided into what may provisionally be called triplets of approximately the same width, each member of a so-called 'triplet,' however, being itself

complex, making the whole magnetic group formed from a single natural line quite complicated. As has already been stated, other investigators have found the degree of separation to vary quite strikingly even for neighboring lines, and although researches with the grating have discovered many complicated lines, the number of these is very small compared to those that appear as simple triplets. Professor Michelson maintains in defense of his methods that the resolving power of a grating is not sufficient to reveal the finer structure of the line as indicated by the interferometer. This last is no doubt true, but on the other hand the interferometer method is exceedingly indirect, and one hesitates before accepting conclusions drawn from an estimated visibility-curve as to the distribution of intensity in such a complicated source as he advocates. In any case, the assumption is involved that the source is symmetrical, and this certainly is not always true. An example is found in the cadmium group 4678, 4800, 5086, and the similar group in the spectrum of zinc. Each of these lines in the spark-spectrum shows a decided shading on the red side, which is retained by each component when they are separated by the magnetic field, making the whole group quite asymmetrical. It has also been shown* that many triplets and quadruplets are asymmetrical in separation. It is quite possible that such cases may account for some of Professor Michelson's results.

It cannot be denied, however, that, although most lines become simple triplets in the field, many are more complicated than the simple theory would indicate, many being fourfold and some at least six-fold, while some seem not to be affected by the field. Several theories have been de-

**The Electrician*, June 18, 1897.

†*Proc. Roy. Soc.*, vol. 63, p. 26.

‡*Comptes Rendus*, vol. 126, p. 181.

§*Comptes Rendus*, April, 4, 1898, p. 997.

*Zeeman, *Proc. Roy. Amst. Acad. Sci.*, Dec. 30, 1899. Reese, J. H. U. Circulars, June, 1899; June, 1900.

vised to account for these variations, which will be discussed later.

Some attempts to classify the spectral lines according to the character and extent of their magnetic separation have met with partial success. Preston* found that in the spectra of magnesium, cadmium and zinc corresponding lines of the homologous groups of three at the head of Kayser and Runge's second subordinate series act in exactly the same way in the magnetic field. That is, the most refrangible line in each group becomes a sharp triplet with the value 10 (relatively speaking) for the ratio $\lambda^2/4\lambda$, the middle line a sextuplet with the value 11.5, and the least refrangible a rather diffuse triplet with the value 18.

A magnetic effect has been noticed on some of the air-lines,† but, with the possible exception of nitrogen peroxide, no effect has been observed on band-spectra, either by emission or absorption methods.

On the continent of Europe most of the work has been done with absorption spectra, particularly with that of the sodium flame; and in this field several most important discoveries have been made.

Egoroff and Géorgiewsky ‡ noticed that the light from a sodium flame in a magnetic field is partially polarized as a whole, i. e., without being dispersed. Lorentz § showed that this phenomenon can be explained by absorption even when the field is uniform.

Righi || and Cotton ¶ have shown how the Zeeman effect may be demonstrated without a spectroscope by passing a plane-polarized beam of white light through a magnetized sodium flame or absorbing gas.

* *Phil. Mag.*, vol. 47, p. 165.

† Becquerel and Deslandres, *Comptes Rendus*, vol. 127, p. 18.

‡ *Comptes Rendus*, vol. 124, pp. 748, 949.

§ *Proc. Roy. Amst. Acad. Sci.*, vol. 6, p. 193.

|| *Comptes Rendus*, vol. 127, p. 216.

¶ *Comptes Rendus*, vol. 125, p. 865.

By this method, which is very sensitive, nitrogen peroxide was shown to be subject to magnetic separation.

Macaluso and Corbino* discovered that a magnetized sodium plane rotates the plane of polarization to a very great extent for light whose wave-length is nearly that of one of the *D*-lines. Very close to the absorption-lines the rotation amounts to as much as 315 degrees. The immediate dependence of this phenomenon upon the Zeeman effect is shown in a very beautiful way in Cotton's little book 'Le Phénomene de Zeeman,' although I believe the more general principle that magnetic rotation of the plane of polarization is dependent upon the optical dispersion of the medium combined with a sort of generalized Zeeman effect, is due to Fitzgerald.†

An analogous effect of the magnetized flame upon light passed through it across the lines of force was discovered independently by Voigt ‡ and Cotton §. They found that the flame acts like a uniaxial crystal; that is, it introduces a phase-difference between waves polarized parallel and perpendicular to the lines of force. This phase-difference increases very rapidly as the wave-length approaches that of one of the *D*-lines. The explanation of this is also given in Cotton's book.

When we review the experimental facts concerning the effect of magnetism upon light we find many things inconsistent with the elementary theory first given by Lorentz. The equation which he obtained indicated that all spectral lines should become triplets under the influence of the field, and that the separation should vary as the square of the wave-length and as the strength of the field. On the contrary we find a considerable number of lines which

* *Comptes Rendus*, vol. 127, p. 548.

† *Proc. Roy. Soc.*, vol. 63, p. 31.

‡ *Wied. Annal.* No. 2, 1899, p. 345.

§ *Comptes Rendus*, vol. 128, p. 294.

become more complicated than triplets as well as some that are apparently unaffected; moreover the separation is very far from varying as the square of the wave-length, and recent work has shown that in some cases at least it is not proportional to the strength of the field.* In spite of these inconsistencies, however, we do not feel called upon to abandon the theory of electrified ions, for we must bear in mind that Lorentz's expression was deduced from assumptions which can hardly be realized in nature. He assumed a molecule of the simplest possible kind, consisting of a single positive or a negative ion acted upon by a central force proportional to its displacement and an electromagnetic force due to the external field equal in magnitude and direction to that which would act on a conductor carrying a current equal to the product of the velocity of the ion by the charge which it carries. Now it seems reasonable to suppose that the central force varies directly as the first power of the displacement because if it varied as any other power the period of vibration would change with the amplitude, and the spectral lines would change their position when the source of light became brighter, which has never been observed. The assumption that the same forces act on a particle carrying a charge e with a velocity v as would act on a conductor carrying a current of strength ev in the same direction is justified for comparatively low velocities by Rowland's experiment in Berlin in 1876. It seems utterly impossible, however, that a molecule should consist of a single ion, for in very few cases does the spectrum of an element contain less than twenty lines in the visible spectrum, and in the iron-spectrum there are thousands of them. A molecule which can vibrate in so many different periods must be exceedingly compli-

* Shedd, *Phys. Rev.*, July, 1899, p. 1; Aug., 1899, p. 86. Reese, *J. H. U. Circulars*, June, 1900.

cated. It is not surprising, then, that our simple theory is inadequate to account for the facts. Lorentz, in fact, knew this and instituted* a theoretical research on more general grounds before its insufficiency had been shown by the discovery of the quadruplet and other complications. He found that if the molecule naturally possessed more than three equivalent modes of vibration—that is, if it could vibrate in more than three ways with the same period—then the single spectral line corresponding to this period would become more than three-fold under the influence of magnetic force. Professor Lorentz does not regard this explanation as satisfactory, owing to the difficulty in conceiving a system having this property.

More recently Voigt† has proposed a theory which accounts for all the observed phenomena and is especially interesting in that by it he predicted cases of asymmetry found by Zeeman and others. Unfortunately the theory does not give any mechanical conception of the subject, merely consisting of the introduction into the equations of motion of terms of arbitrary form, which have no apparent justification.

It is comparatively easy to treat the case of a molecule composed of two ions carrying equal charges of opposite signs, and, in fact, Professor Rowland has lately given such a treatment before his students at Johns Hopkins University, but it leads to no new results as regards the Zeeman effect. Any case more general than this is very difficult.

HERBERT M. REESE.

EUROPEAN APPLE TREE CANKER IN AMERICA.

SHORTLY after bulletin No. 163 of this station, entitled 'A New York Apple Tree

* *Wied. Annal.*, vol. 63, p. 278. *Astroph. Jour.*, vol. 9, p. 37.

† *Wied. Annalen*, No. 2, 1899, p. 345; No. 6, 1899, p. 352; No. 9, 1899, p. 290; No. 2, 1900, p. 376, and p. 389.

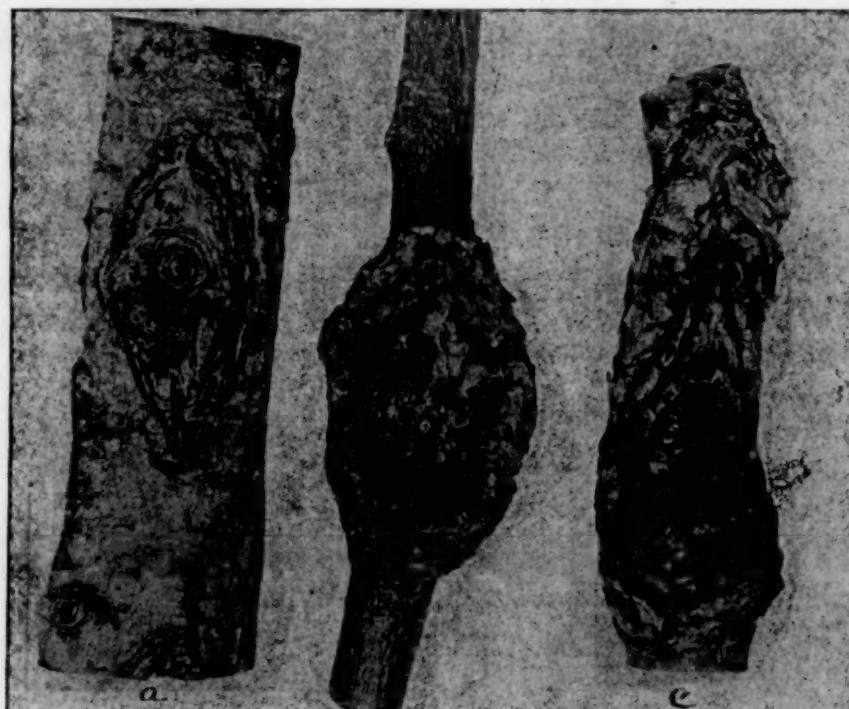
Canker,' was distributed, the writer received specimens of diseased apple limbs from various parts of the United States and Canada. Among the rest was a specimen from Nova Scotia which was noticeably different from any that I had yet seen. The injury was about six inches long on a limb two inches in diameter. Within the diseased area was a series of six ridges or convolutions in the wood surrounding a central starting point, each one of which evidently marked a year's growth of a parasitic fungus. The fungus, *Sphaeropsis m-*

lorum Peck., which has been shown to be the cause of the common New York apple tree canker, is more active in its growth. With this disease large areas of bark may be destroyed and the wood laid bare, or in other instances the bark may be much swollen and roughened, but the form of injury described above does not occur.

The appearance of the diseased limb, which was similar to that shown in Fig. 1 at *c*, strikingly resembled the work of *Nectria ditissima* as illustrated and described by European writers. However there was

no fungus fruit in evidence, and as I was unsuccessful in obtaining more specimens the matter was dropped for a time.

In the latter part of May several specimens of diseased apple limbs were received from East Homer, Cortland County, N. Y., that were similar in appearance to the one from Nova Scotia, but in addition many portions of the dead bark and wood were thickly studded with the minute, deep red perithecia of a *Nectria*. Among the specimens were examples of recent infections as is shown at *a*, in the figure, as well



as cankers of several years standing. The perithecia were abundant on all these specimens, so there seemed little doubt but that the *Nectria* was the cause of the diseased condition.

On visiting the locality it was found that the fungus was evidently confined to a small area and but few additional specimens were secured.

Through the kindness of Professor F. C. Sears, Wolfville, N. S., more specimens of the diseased apple limbs were obtained from that locality in June and the perithecia

of the *Nectria* were found to be abundant on them. Professor Sears writes that this form of canker is doing serious damage in some of the orchards of the Annapolis Valley.

Specimens of the diseased branches were sent to Dr. R. Hartig, Munich, Germany, for identification, who writes that the cankers are caused by the fungus *Nectria ditissima*.

So far as I know this fungus has not as yet been recorded as occurring on apple trees in America, and its appearance in our orchards is of great practical importance since it is a serious pest to European fruit growers.

W. PADDOCK.

EXPERIMENT STATION, GENEVA, N. Y.

ZOOLOGY AT THE AMERICAN ASSOCIATION.

THE following papers were presented before Section F during the recent meeting at New York:

Sketch of the History of Statistical Inquiry of Evolution: By C. B. DAVENPORT, University of Chicago. The paper will appear in full in SCIENCE.

The Variation of Synapta: By C. L. EDWARDS, Trinity College. In the absence of the author this paper was read by title.

Variation among Hydromedusæ: By CHARLES W. HARGITT, Syracuse, N. Y. To be published in SCIENCE.

Variations in Jaws of Neries limbata: By MARIAN HEFFERAN, University of Chicago. Presented by C. B. DAVENPORT.

A quantitative study of variation made upon the species *Neries limbata*, collected at Cold Spring Harbor during the summer of 1899, gave the following results:

The character chosen for investigation was the number of teeth on the exsertile jaws. These number from 6-14 on each of the two jaws and were distinguished both for the sake of convenience and for purposes of comparison into definite teeth,

those which occupy the distal half of the jaw and which are clearly separated from each other, and the indefinite teeth at the base of the jaw which are covered by a transparent horny layer.

The typical condition of the total number of teeth of 400 specimens of *Neries limbata* of Cold Spring Harbor is a curve of type I. or type IV., with a slight skewness in a negative direction from the mode 10. In case of the calculation of the right total teeth a transition from a curve of type IV. to an equally serviceable one of type I. could be made by dropping one extreme individual out of 400. The teeth on the right jaw appear to be slightly more variable than those on the left. The least variation is shown by the indefinite teeth. The degree of correlation between the two jaws is, on the whole, rather high, 0.820. Correlation is closer between the indefinite than between the definite teeth. A negative correlation exists between the definite and indefinite of the same jaw, that is, a small number of definite teeth is associated with a large number of indefinite and vice versa. An inverse relation also exists between the number of definite teeth and the age of the animal, older animals presenting fewer definite teeth.

This result as well as those of observation of many specimens showing many irregularities in the teeth, point to the conclusion that a process of erosion of the extreme teeth forms a large factor in the variation of the definite and perhaps indirectly of the indefinite teeth. A difference in the number of teeth in respect to the age of the animal has rarely been recognized in description heretofore and would be naturally overlooked unless a large number of specimens was examined. Little value can thus be placed upon the statements made in regard to the number of teeth in a large number of species where only a few specimens were found.

Some Cases of Saltatory Variation: By C. H. EIGENMANN and ULYSSES COX, Indiana University.

1. A specimen of *Rana pipiens* 54 mm. long has the forearm and hand of the right side duplicated. This arm is carried in a sling formed of a loop of the skin of the breast 4 mm. wide. This is a pathological abnormality rather than a variation that leads to the mutation of species.

2. A specimen of *Ameiurus natalis* 120 mm. differs from normal specimens in the total absence of all traces of the ventral fins. This is a saltatory variation which if prepotent might give rise to a race of catfish without ventrals, which would be considered generically different from the parent stock. This specimen is of interest in connection with the next case.

3. A variation of great importance and no small interest is presented by nine specimens of *Ameiurus melas*. These were collected at random from among a large number in Mitchell's Cave, Kentucky. Each one possesses one or more supplemental nasal barbels. These might give rise to the supposition that they are the direct result of the cave life, but an examination of all the data makes it probable that we are dealing with a coincidence of a cave habitat and a prepotent saltatory variation that appears adaptive to a cave existence. The conclusions arrived at concerning these specimens are: (1) the variation is saltatory. (2) it is bilateral without reaching perfect bilateral correlation; (3) it is improbable that the variation arose independently in each of the specimens; (4) the variation probably arose in one of the ancestors of the specimens; (5) admitting (4) the saltatory variation arising in an ancestor was prepotent to a very high degree.

Variation and Correlation in the Tibial Spines of Melanoplus: By C. B. DAVENPORT, University of Chicago.

This paper, embracing work done in connection with Miss Ora H. Hubbard gives the constants and their probable errors of the distributions of frequencies of the spines of the inner and outer rows of spines on the right and left-hand tibiae of *Melanoplus femur-rubrum* from Newport, Rhode Island. The correlations of the number of spines in the various rows was determined quantitatively and the interesting result obtained that there is a greater correlation between rows symmetrically placed with reference to the plane of symmetry of the whole animal than there is between rows so placed with reference to the plane of symmetry of the single leg. Finally the range of individual variation is greater than the range of variation of the modes of various species of the genus *Melanoplus*; consequently in the individual variation of the one species there is provided material for the various typical numbers of spines found in all species of the genus.

Variation in Io: By C. A. Adams. To be published in full.

On the Origin and Distribution of Leptinotarsa decem-lineata Say, and the part that some of the Climatic Factors have played in their Dissemination: By W. L. TOWER, University of Chicago. To be published in SCIENCE.

A New Eyeless Isopod Crustacean from Mexico: By A. S. PACKARD, Brown University.

Some years ago I received through the kindness of Professor A. L. Herrera, of the City of Mexico, an isopod crustacean taken from a well at Monterey, Mexico. It appears to be a true *Conilera*, and may be named *Conilera stygia*.

It is totally eyeless, and adds another to the blind fauna of our caves and wells. Hitherto the genus has been represented by but a single species, inhabiting the British coasts. Compared with Bates and West-

wood's figure of *C. cylindracea*, the body is longer, the antennæ much longer, reaching to the middle of the first thoracic segment, those of the second pair nearly to the middle of the seventh thoracic segment. Only the first three pairs of legs are short, with a very thick hand; the four hinder pairs of legs are long, slender. The two last divisions of the pleopods are unequal, the outer division very narrow, but a little more than half as long as the broad inner division or endopodite. Length of body 25 mm.; breadth 5 mm.

This form is like most if not all other blind or eyeless arthropods in having a longer body, antennæ, and legs in compensation for the loss of eyes.

A Contribution to the Fauna of the Caves of Texas: By C. H. EIGENMANN, Indiana University.

In the early part of September, 1899, I visited San Marcos, Texas, to secure if possible some living specimens of the cave Salamander occasionally thrown out of the Artesian well of the United States Fish Commission. This well taps an underground stream about 190 feet from the surface. No specimens of the Salamander *Typhlomolge* came to the surface during my stay, but I received two living specimens from Superintendent J. L. Leary.

Besides the Salamander three species of Crustaceans had been secured from this well. These were described preliminarily by Mr. Benedict, *Proc. U. S. Nat. Mus.*, Vol. XVIII. One of these, *Palaeomonetes antro-rum*, is very abundant and many are thrown out from the well each day. The eyes of this species are degenerate far beyond those of the blind *Cambarus pelucidus* of the Mississippi valley caves. They will be described elsewhere. The second one *Ciralonides texensis* is not nearly so abundant as the first. During my stay of three days I secured several specimens. It can readily

be seen in the receiving basin of the well when thrown out.

The third *Crangonyx flagellatus* is much rarer and no specimen was secured during my stay. Instead however a single specimen of a related species (*Crangonyx bowersii*) was secured.

These are all the species that can readily be seen with the naked eye, when swimming about the receiving basin. A screen of bolting cloth (No. 2) placed over the outlet for a short time secured a number of additional species, viz, the front half of a new species of *Casidotea*, two new species of *Copepoda*, a *Cypridopsis* and a Crustacean that defied identification and was later lost, as well as a flat worm. The evidence from the screening is that there is yet a rich subterranean fauna to be obtained from this well.

There is near the well a spring arising evidently from the same source by the side of which the well is insignificant in its yield of water. No blind creatures have been recorded from this spring, and the difficulty in straining its output is much greater than that of straining the well. Through the liberal policy of the Honorable G. M. Bowers and Dr. Hugh M. Smith, of the United States Fish Commission, a plankton net is now in use at the San Marcos well, and we may expect other additions to the fauna of the well and the underground stream it taps.

Near San Marcos are two small caves. Ezell's cave was formerly open to the public and provided with steps and other facilities for entrance. The opening leads into a pit about forty feet deep, with one side, that nearest the entrance, quite perpendicular, but with some projecting rocks. At the bottom of this pit and at the side furthest from the entrance a smaller opening led downward to the water, which was said to be about one hundred feet from the entrance. The Texas variety of small boy

has found amusement in rolling rocks down the entrance thus smashing the steps and closing the former opening at the bottom of the first series of steps. It was necessary to take a side branch to reach the water. This side branch, for sufficient reasons, I did not take to its end, although my assistants managed to get through to the water without, however, securing any specimens. I was amply rewarded for not entering the deeper recesses by finding in the twilight of the entrance pit an abundant cave fauna.

Not far from this cave is Beaver cave. This is a winding, twisting channel of no great height or width. All the available time was devoted to securing specimens and the cave was not followed to the end. There is no water except in a pit dug in the cave.

Animals, though few in species, were surprisingly numerous in both these caves. The following species were secured in the well and caves:

1. A flat worm sp.?—Artesian well.
 2. *Mollusca*.
 3. *Vitreola petrophila*, Bland, pale var.
 4. *Bifidaria contracta* Say.
 5. *Helicodiscus Eigenmanni* Pilsbry,
n. sp.
 6. *Cypridopsis vidna obesa* Brady and
Robertson.
 7. *Cyclops cavernarum* n. sp.
 8. *Cyclops Learii* n. sp.
 9. *Cæcidotæa smithii* n. sp.
 10. *Ciralonides texensis* Benedict.
 11. *Brackenridgea cavernarum* n. sp.
 12. *Crangonyx Bowersii* n. sp.
 13. *Palæmonetes antrorum* Benedict.
 14. Larval crustacean, unidentified.
 15. sp.?—Ezell's Cave. Beaver Cave.
 16. *Theiridium Eigenmanni* Banks
 - n. sp.
 17. *Degeeria cavernarum* Pack.
 18. *Nicoletia texensis* n. sp.
- Crustacea.*
- Arachnida.*
- Ezell's Cave.*
- Beaver Cave.*
- Thysanura.*
- Ezell's Cave.*
- Beaver Cave.*

Orthoptera.

19. *Ceuthophilus palmeri* Scudder.
- { Ezell's Cave.
Beaver Cave.

Diptera.

20. *Larval Chironomus*.—Artesian well.

Vertebrata.

21. *Typhlomolge rathbuni* Stejneger.—Artesian well.

Convergent Evolutions as illustrated by the Blind Lizard Rhineura: By C. H. EIGENMANN, Indiana University.

Living specimens of the blind lizard *Rhineura* show a great similarity in color, shape and method of progression to earth-worms which they also resemble in habits. Living specimens were exhibited.

The Development of the Eyes in the Blind-fish Amblyopsis: By C. H. EIGENMANN, Indiana University.

The eye is perfectly normally outlined. A lens is normally developed but does not become located within the iris. It degenerates early, disappearing before the fish exceeds 10 mm. in length. The optic nerve is normally developed, and retains its connection with the eye and brain till maturity. It gradually becomes attenuated, and in the old a connection between the eye and brain cannot be traced. The vitreous body does not become developed to any extent. The secondary optic cup at all times remains a shallow depression. An outer reticular layer does not develop and cones are uncertain in their development.

The Eye of the Cave Salamander Typhlotriton: By C. H. EIGENMANN, Indiana University.

The eyelids are closing over the eyes. The eye is normally developed. The retina is normal in the young but with the metamorphosis or shortly thereafter the rods and cones disappear.

Some of the Internal Changes which accompany Ecdysis in Insects: By W. L. TOWER, University of Chicago.

The most important of the changes which precede ecdysis in insects is the develop-

ment of the exuvial glands. These are unicellular hypodermal glands, usually pear-shaped, with the smaller end prolonged into a tube which opens through a pore beneath the cuticula. Sometime before ecdysis these glands begin to grow larger, and the nuclei have well developed membranes with clearly defined chromatin skeins. In the few days immediately preceding ecdysis the glands enlarge rapidly, owing to the secretion of an albuminous fluid within the cells, and the nuclei become amoeboid, sometimes branching in fine dendritic processes among the globules of the exuvial fluid. The time for ecdysis having arrived the glands pour out their contents gradually until there is a thin layer of the exuvial fluid separating the old cuticula from the hypodermis. The hypodermis now rapidly secretes a new layer of cuticula, and thus the whole animal is covered with this fluid, which enables it to crawl out of its old shell with ease.

These exuvial glands occur on all parts of the body, but are most numerous on the pronotum. After ecdysis they become small and rounded, with densely staining nuclei.

The point of interest now is the secretion of the secondary layer of the cuticula, which forms the real strength of the insect's skeleton. During ecdysis and for a short time thereafter the only cuticula is an extremely thin layer which is easily bent or torn, but about thirty minutes later the deposit on the secondary layer begins and continues until near the middle of the instar. This layer is often ten times the thickness of the primary cuticula, and seems to be like a cellulose layer, giving in some cases a 'cellulose test.'

Sugar and Muscle Fatigue: By FREDERIC S. LEE, College of Physicians and Surgeons, New York.

The origin of muscular energy, whether

from nitrogenous or non-nitrogenous substance, has been disputed. There has likewise been much discussion over the respective parts played by the two recognized causes of muscle fatigue, namely, the destruction of substance necessary for contraction and the poisoning of the muscle by so-called fatigue products. Recent experimental evidence both for and against the idea that sugar is an important source of bodily energy has been brought forward by others. The author, together with Mr. C. C. Harrold, has studied the problem by experiments on cats which had been put under the influence of the peculiar drug, phlorhizin. It is known that this drug removes the carbohydrates from the body. Fasting animals were put under the influence of the drug, were then killed, and the contractile power of the muscles, which continues normally for several hours after death was then tested. The muscles of well-phlorhizinated animals were found to have a contractile power much less than normal, and in this respect resembled muscles in a pronounced state of fatigue. That this result was due to the removal of carbohydrate from the muscles rather than to a mysterious specific action of the drug on the muscle protoplasm is rendered probable by the fact that if dextrose be given to an animal that is well under the influence of phlorhizin the fatiguing effect of the drug is counteracted and the contractile power of the muscles is restored. It seems to be a legitimate conclusion that normally sugar is a source of muscle energy and the destruction of it a cause of muscle fatigue.

The supposed connection between the oncoming of rigor mortis and the loss of carbohydrate is confirmed by these experiments. A well phlorhizinated animal may begin to go into rigor within five minutes after death, and the rigor is often complete within a half hour.

The Structure of the Poison Glands of Schilbeo-
des gyrinus: By HUGH DANIEL REED,
 Cornell University.

The poison gland is supposed to be in the axil of the pectoral fins. It is in reality just beneath the epidermis and almost entirely surrounds the spine. Both dorsal and pectoral spines have poison glands. The gland tissue is composed of large, coarsely-granular, doubly-nucleated cells. Each poison cell is surrounded by a layer of spindle-shaped epithelial cells. The clavate cells of the skin are identical in structure with the poison cells. They are wanting in those places which are entirely covered or protected by other organs. From their resemblance in structure to the poison cells and their distribution, it is probable that their function is one of protection. The poison cells are regenerated from the cells of the epidermis.

Before the poison can be effectual the cell membranes must be destroyed, for there is no duct leading from the gland to the exterior. The spine is entirely covered by epidermis which has to be punctured.

Development and Relations between the Intestinal Folds and Villi of Vertebrates: By W. A. HILTON, Cornell University.

Folds, villi and valvulae conniventes are convolutions of the mucosa alone, other foldings involving the muscular coats not being considered. Folds and villi are homologous, villi being more specialized and occurring usually in otherwise highly specialized vertebrates. Several influences upon size and form of villi are easily recognized, such as the influence of food and size of the animal. By phylogenetic and ontogenetic study of a number of species it is found that there are at least two ways in which the villi are formed from folds. The more usual way being like that which takes place with the chick, that is, straight folds becoming more and more wavy until very

zigzag folds are produced and villi formed from these by separations which take place at the tip of the fold angles downward.

Villi are present in the large intestines of most mammals sometime before birth, and occur also in the appendix vermiciformis of man before birth, possibly showing the appendix of man to be an atrophied part of the cecum.

*Hystolysis of Muscle in the transforming Toad (*Bufo lentiginosus*):* By LOUISE KATZ, Ithaca, N. Y.

It is shown in this paper that while the outward changes in transformation are exceedingly rapid, taking place in about three days, the internal changes are in process for a considerably longer period. The first sign of muscle change is a myotome near the base of the tail opposite the growing legs. Here a few fibers, often but a single one, occur on each side. Later, when the legs are about three-quarters grown, degenerating fibers are scattered all along the tail, but are most numerous at the tip.

Forms of degeneration; there are four quite well-marked types:

1. Mass degeneration, in which the whole fiber degenerates in one or more large masses.
2. Degeneration with transverse bands of degenerating substance, alternating with bands of normal muscle.
3. Breaking of the fibrillæ into smaller fragments, the so-called sarcolytes.
4. Transformation into transverse bands with intermediate gaps as if liquefaction had taken place.

In all the types the changes appear to be intrinsic in the muscle itself; homogeneous material is produced, reacting characteristically with the various stains and fixers, and disappearing by liquification *in situ*. Thus far I have found no evidence of fragmentation of the nuclei, nor marked in-

crease in protoplasm as described by various investigators. In many fibers, however, showing no other signs of degeneration, the nuclei were no longer evenly distributed, but collected in a longitudinal row near one end. Fat occurs as a late product of degeneration. There is no evidence that phagocytes play any part in the degeneration process occurring in the muscle.

The Biogenetic Law from the Standpoint of Paleontology: By JAMES PERRIN SMITH, Stanford University, California.

This paper was a general discussion of the repetition of ancestral characters in the ontogeny of the individual; difficulties of interpreting and correlating stages of growth of the individual with ancestral genera with illustrations taken from the life history of fossil invertebrates and an exhibition of ontogenetic series of fossil ammonites, and a discussion of the meaning of the stages of growth.

Reconsideration of the Evidence for a Common Cynosaur-avian stem in the Permian: By HENRY F. OSBORN, American Museum of Natural History, New York City.

This paper will be printed in the *American Naturalist*, August, 1900.

Relation of Dinosaurs to birds as discussed since 1864.

History of opinion.

Theory of descent from a common stem form, Huxley.

Descent from Iguanodontia, Baur.

Gradual reaction of opinion to the view expressed by Fürbringer in '88, that Dinosaurs and birds have descended from a common reptilian ancestor.

Review of all the osteological resemblances between birds and Dinosaurs. Grounds for a reconsideration of the problem.

(a) The clawed quadrupedal ancestry of birds.

(b) Structure of the Permian Progano-sauria.

(c) Origin of the bipedal type.

(d) Probability that birds and Dinosaurs sprang from a common bipedal type in the Permian period constituting dinosaur-avian stem.

The Reptilian Origin of Mammals as illustrated in the Structure of the Occipital Condyles: By HENRY F. OSBORN, American Museum of Natural History, New York City.

Huxley's theory of the amphibian origin of mammals recently revised by Hubrecht and Kingsley.

Difficulties in the theory.

Theory of derivation of mammals from the *Anomodontia*.

Tripartite structure of the condyles in these reptiles.

Essential tripartite structure of the condyles in certain mammals.

Mammal condyle of amphibian and not of reptilian origin.

Structure, Relationship and Habits of the Eocene Creodont, Patriofelis: By HENRY F. OSBORN, American Museum of Natural History, New York City.

This paper will be printed in *Bulletin of the American Museum Natural History*.

Discovery of a complete skeleton of Patriofelis, Seeley by the American Museum Expedition.

Full description of this skeleton by Dr. J. L. Wortman with theory of aquatic habits of the life and of the probable relationship of the aquatic carnivora.

Re-study of the skeleton.

(a) Skull and dentition of feline type.

(b) Feet transitional between raccoon and feline type.

(c) Probable terrestrial habits of this type.

(d) Insufficient ground for theory of relationship of the *Pinnipedia*.

Phylogeny of the Rhinoceroses of Europe:

By HENRY F. OSBORN, American Museum Natural History, New York City.

This paper will be printed in the *Bulletin* of the American Museum of Natural History.

Difficulties in a systematic arrangement of Rhinoceroses resulting from recent discoveries.

Necessity of phylogenetic classification.

Great antiquity of separate phyla.

Our ignorance of the stem form.

Revision of the family Rhinocerotidae into seven subfamilies representing different phyla.

Theory of migration from Africa.

On the Inflection of the Angle of the Jaw in the Marsupialia and other Mammals: By B. ARTHUR BENSLEY, Columbia University, New York City. To be printed in SCIENCE.

On a Phylogeny of the Marsupialia: By B. ARTHUR BENSLEY, Columbia University, New York City. (Abstract withdrawn.)

On the Composition of the Monotreme Skull: By B. ARTHUR BENSLEY, Columbia University, New York City. (By title.)

Lymphosporidium truttae, nov. gen. nov. sp.

The Cause of a Recent Epidemic among Brook Trout: By GARY N. CALKINS, Columbia University, New York City.

In October, 1899, my attention was called to a disastrous epidemic among the brook trout (*Salvelinus fontinalis*) in a Long Island Hatchery. Investigation showed the cause of the trouble to be a new genus which I have placed provisionally with the *Serumsporidia* (L. Pfeffer) among the Sporozoa, a class of parasitic Protozoa.

The spores of the parasites accumulate in the lymph spaces of the fish and prevent normal nourishment of the tissues. This leads ultimately to ulcers of various shapes and sizes.

The spores give rise to 8 sporozoites or germs each of which develop into an adult amœboid individual about 25 mu. (.001 inch) in length. This penetrates the bundles of unstriped muscle cells of the digestive tract and becomes mature. At maturity a spore-forming cyst is developed in the lymph and the spores are carried throughout the entire animal.

The epidemic which lasted from May until December, 1899, killed off all the fish in the hatchery. The origin, preventive measures and remedies were not discovered.

The Primitive and Secondary Types of Vertebrate Embryos: By PROFESSOR CHARLES S. MINOT, Harvard Medical School, Boston, Mass.

This paper gives a comparison of the development in marsipo-branches, ganoids, dipnoans and amphibians as representing the primitive type of vertebrate development. The Selachian, Teleost, Sauropsidan and mammalian types are regarded as secondary modifications. It also includes a comparative study of the form of the embryo in the Ichthyopside and Amniota.

A Partial Phylogeny of the Genus Cancer.

By A. S. PACKARD, Brown University.

A comparison of the miocene tertiary species of cancer (*Cancer Proavitus* Pack.) with the two species now living in the waters of Vineyard Sound, brings out the interesting fact that the extinct species is the stem or ancestral form from which the recent species have apparently descended.

Cancer Proavitus presents characters in which it resembles *C. borealis* as well as *C. irroratus*. It resembles *C. borealis* in the higher, more pointed granulations on the postero-lateral margin of the carapace, and in the quite high and sharp spines on the ridges of the hand as well as the numerous setiferous spines and hairs; on the other

hand it is similar to *C. irroratus* in the shape of the nine teeth on the antero-lateral margin of the carapace, and in the straight postero-lateral margin of the same. It is rounder, narrower, the carapace more convex, and the body in general more hairy than either of the existing species.

It thus seems most probable that the miocene species, being a more generalized, composite form, is the ancestor from which, either toward the end of the pliocene or the beginning of the quaternary period, the two living species sprang. *C. irroratus* has inherited the exact shape of the lateral teeth and the shape of the postero-lateral margin of *C. proavitus*, while *C. borealis* has retained the higher spine-like granulations or submuricate feature of the carapace and hand and the hairiness of the body.

On the whole the evidence that our two northeastern species have descended from a much more rounded, convex, and hairy miocene form living in the same geographical area seems to be well established.

It would be most interesting to compare this fossil species with very young individuals of our living species, but after inquiry I find that they are not in existence in our museums. It is to be hoped that specimens of the very young may be collected and compared with the fossil species. It is known that in cancer the body grows wider with age.

A Review of the Problem of Sex Cells in the Hydromedusæ: By CHARLES W. HARGITT, Syracuse University.

A former paper before this section (*Proc. A. A. A. S.*, 1889) set forth the view that for *Eudendrium ramosum* the ova originate in the endoderm. This was not passed without controversy. As a preliminary contribution it was not emphasized at that time. After some years the problem was again taken up in connection with related problems and four species of *Eudendridæ*

examined, namely, *E. ramosum*, *E. racemosum*, *E. dispar*, and *E. tenue*.

As a result it may be said that while in *E. ramosum* and *E. tenue* the ova arise strictly in the endoderm, and never at any time find their way into the ectoderm, in the species *racemosum* and *dispar* these products are found abundantly in both tissues. However, it must not be overlooked that in every case the primitive ova are found in the endoderm, and only during the process of growth do they migrate into the ectoderm. In view of these facts it would seem to be a just inference that their origin is endodermal, though in these two species they may migrate into the ectoderm and complete development in that position.

Any glance at the literature will show a strange confusion as to data. Weismann himself has contributed to this, due in part to confusion arising in methods of work, done in part upon optical sections rather than actual. Similar errors have doubtless been due to similar methods by earlier as well as later observers.

However, it seems that in *Hydromedusæ* there is a great variation in this matter. For whether the hydroid or medusa be the more primitive, or likewise as to the more primitive character of hydro- or scyphomedusa, there must have been a time when there was a transition from the one to the other. If therefore such transitions have arisen phylogenetically, is it not possible that among the more plastic genera such transition may continue at the present time?

In any case it would seem to be extremely rash to predicate any such character as a diagnostic and distinctive difference between the sub-classes *Hydromedusæ* and *Scyphomedusæ*.

The Mosaic of the Single and Twin Cones in the Retina of Micropterus salmoides: By GEORGE D. SHAFFER, Indiana University. In the *American Naturalist* for February,

1900, Eigenmann and Shafer described the different patterns of twin and single cones found by them in the retina of several different species of fishes. No attempt was made by them to determine the modification of any of the patterns in different parts of the same eye of any species.

The present paper deals with the modification of the pattern in the large-mouthed black bass, *Micropterus salmoides*. The questions more particularly dealt with are:

I. Is the pattern of the twin and single cones the same over the entire retina?

II. What relation does the direction of the rows of cones which go to make up the pattern bear to the surface of the eye?

III. What is the difference between the number and size of the elements in the young and old fish?

Several series of tangential sections were cut from a band passing from the anterior edge of the cornea around the back of the eye to the posterior edge of the cornea; other series were secured from a band passing from the upper edge around the lower edge of the cornea.

I. The variation of the pattern.

The general variation in the twin and single cones in this species is that of Eigenmann and Shafer's pattern D. In this pattern the twin cones are so arranged that if the lines joining the centers of the components of a twin (*i. e.*, the axes) were continued they would form a square; a single cone is placed in the center of this square. The division lines separating the components of the twin cones thus point toward the single cone. That is, the division lines form right angles with the sides of the square. This ideal pattern for this species is most nearly approached over the anterior and posterior surfaces of the eye. As we go from the anterior and posterior edges of the cornea toward the wider parts of the eye, the pattern changes from a square to a rhombus. Its area at the same

time increases until we approach the back of the eye itself, where the patterns are again smaller and closer together; even crowded.

Immediately at the upper and lower edges of the cornea the division lines separating the two parts of the twin cones instead of pointing toward the single cones are turned until they point almost directly toward each other. At these points, the square has varied to a rhombus of which the two obtuse angles are almost one hundred and eighty degrees. The single cone remains in the center of this modification of the square. As we go from the upper and lower edges of the cornea toward the back of the eye, the rhombus is quickly changed into a square again. In other words the double cones soon have their division lines turned again in the direction of the single cones. Except very near the cornea, the patterns in the band from the upper to the lower edges of the cornea are much more crowded than in other parts of the eye.

II. The relation of the pattern to the eye.
A study of the modification of the pattern as described in the first section shows that such a modification is brought about on the surface of the eye if the axes of the twin cones lie on two series of circles. The center of one of these series of parallel circles lies approximately at the upper edge of the iris, the center of the other approximately at the lower edge. These two series of circles cut each other at right angles near the anterior and posterior edges of the iris and cut each other at more and more acute angles at the top and bottom of the iris. The extreme modification that would be brought about by the close adherence of the twins on these lines is relieved by the interpolations of additional double rows of single and twin cones.

III. The patterns in the young and old fish. A comparison of the eye of a young

fish 60 mm. long which measured 3.8 mm. from cornea to optic nerve and 4.7 mm. longitudinally with the eye of a fish 335 mm. long measuring 10 and 13 mm. respectively along the lines measured in the smaller specimen shows (1) that no new elements are added during the growth of the eye; (2) the distance between the elements increases about in proportion to the increase in the surface of the eye. The ratio between the surfaces of the smaller and larger eye is about 1:0.144, the average ratio between the distance from center to center of two elements of the pattern in the small and large eye is 1:0.164; (3) on the average the ratio between the size of the elements in the small eye and large eye is 1:2.

CONCLUSIONS.

I. The pattern varies in shape from a square on the anterior and posterior edges of the eye to a rhombus on all other parts of the eye except where rows of cones have been interpolated; and it is largest at the middle of the anterior and posterior faces of the eye.

II. The cones are arranged in rows which correspond to circles formed on the surface of the eye by two sets of parallel planes. One set of these planes is perpendicular to an axis passing from the upper edge of cornea through the center of the eye to the back and the other set of planes is perpendicular to an axis passing in a similar manner from the lower edge of the cornea.

III. As the surface of the eye increases in size toward old age the area of the patterns increases in about the same proportion. No new elements are added.

Development of the Lungs in the Frogs, Rana Catesbeiana, R. sylvatica, and R. virescens:
By MARGUERITE HEMPSTEAD, Meadville, Pa.

The principal features of the development of the lungs in the American frogs studied may be stated as follows:

1. The formation of the respiratory apparatus is similar to that in the toad, but differs from the latter in having the communication with the pharynx formed very early in larval life instead of at the end as in the toad.

2. The respiratory apparatus arises as a solid downgrowth from a solid portion of the pharynx, which is unlike the formation of the lungs in *Bombinator* as described by Goette, and unlike the description of the process in other European forms in all the accounts available for reference.

3. The lung rudiment is single and solid, and not a pair of hollow evaginations as described by Marshall.

*Development of the Lungs in the Common Toad *Bufo lentiginosus* and in the Tree Toads (*Hyla pickeringii* and *Hyla versicolor*):* By SIMON HENRY GAGE, Cornell University.

With the tree toads the pharynx becomes hollow before the external gills are absorbed, and the lungs become hollow and open into the pharynx before the external gills disappear.

In *Bufo* the lungs and pharynx very early become hollow, but the larynx remains solid and has no communication with the pharynx until the tail is almost wholly absorbed and the young toad is almost completely transformed. The connection of the lungs with the pharynx seems to be one of the last acts of metamorphosis. When the larynx opens into the pharynx it is lined with ciliated epithelium, apparently the epithelium is non-ciliated before the opening is established.

In the ciliation of the oral cavity and the pharynx of the toad (*Bufo*) the columnar ciliated epithelium spreads from the oesophagus into the pharynx and the mouth.

The Chronological Distribution of the Elasmobranchs: By O. P. HAY, American Museum Nat. History, New York City.
There is first presented a diagram which

shows, by means of curves, the number of species of fossil elasmobranchs which are known to have existed during each of the geological periods.

There is also presented a table which contains lists of the genera of Elasmobranchs which occur in each of the geological periods.

The portion of geological time occupied by each of the families is discussed.

Some conclusions are drawn bearing on classification of the Elasmobranchs.

The Lower Temperature Limits of Incubation for the Egg of the Common Fowl: By

CHARLES LINCOLN EDWARDS, Trinity College.

Since the time of the Egyptians it has been known that warmth is the chief factor in incubation of eggs of birds. Modern investigators have established 35 degrees C. to 39 degrees C. as the normal temperature range. Rauber ('84) gave as the optimum 38 degrees and minimum 25 degrees. It is well known that cold, if not too intense or too prolonged, will slow development.

Dareste gives 28 degrees C. as the physiological zero for the hen's egg, below which, of course, there is no development.

Kaestner produced anomalies by interrupting the normal development through cooling the egg.

Warynski showed that yolk rises because of change in specific gravity and sticks to the vitelline membrane, thus producing arrest of development and consequent monsters.

Féré ('94) established the ratio of development at abnormal temperature to the stage at normal of 38 degrees, as follows:

Temperature:

34° 35° 36° 37° 38° 39° 40° 41°

Index of development:

0.65 0.80 0.72 ? 1.00 1.06 1.25 1.51

In my experiments a Cyphers incubator together with a calibrated thermometer divided to one-fifths of a degree was used.

Incubation 1. In 12 eggs incubated at 30.75 degrees C. for 7 days, 19 hours, chicks reached an average of about one-half the normal development. Over half of this clutch of eggs developed hydroptic vesicles in the blastoderm. These arise from enlarged blood islands in the mesoderm, in which the primitive corpuscles degenerate and the space becomes filled with lymph.

Incubation 2. In 6 eggs incubated at 29½ degrees C. for 5 days, 18 hours, the ontogenetic stage was from the 16- to the 24-hour chick. The cephalic end of the neural groove was trifid in one variate. Lateral branches of primitive groove were developed posteriorly.

Incubation 3. In 12 eggs incubated at 28½ degrees C. for 7 days the ontogenetic stage was from a central area of undifferentiated mesoderm to 27 hours.

Incubation 4. In 10 eggs incubated at 27 degrees C. for 6 days, with the exception of one uncertain anomaly, the greatest development was represented by a primitive streak 1.8 mm. long. Blastoderms vary from 4.5 mm. to 8 mm. in diameter.

Incubation 5. In 9 eggs incubated at 26 degrees C. for 7 days, 19 hours, showed a primitive streak 1.3 mm. long as the greatest development with the exception of one case with open neural folds 1 mm. long. Blastoderms vary from 4 mm. to 7 mm. long.

Incubation 6. In 8 eggs incubated at 25.5 degrees C. for 6 days there was a variation from no development to a primitive streak and groove 1.7 mm. long. Blastoderms vary from 5 mm. to 5.5 mm. in diameter.

Incubation 7. 11 eggs at 25.5 degrees C. for 7 days, 2 hours, 8 developed from a central area of mesoderm cells to a primitive streak 2 mm. long. Of the other three one showed open neural folds and rudimentary brain, one 22 mesodermic somites and one was a 3-day chick. The last three may

have been previously incubated. Blastoderms vary from 4 to 11 mm. in diameter.

Incubation 8. Nine eggs at 24.5 degrees C. for 6 days, 1½ hours gave one primitive streak 1.5 mm. long as the greatest development. Blastoderms vary from 4 mm. to 1 cm. in diameter.

Incubation 9. 11 eggs at 24 C. for 6 days, 19 hours. Blastoderms vary from 5.4 mm. to 7 mm. in diameter. With the exception of a degenerated 2-days chick only 4 of the 11 blastoderms showed a trace of the primitive streak.

The Fishes of Africa as Exponents of former Geographical Conditions: By THEODORE GILL, Smithsonian Institution.

The fishes of Africa represent two very different elements. One is composed of Asiatic types; the other of South American types. The latter indicate a former connection direct or mediate with South America; the latter are in conformity with the present association of the continents.

The Moringuid Eels and their Geographical Distribution: By THEODORE GILL and HUGH M. SMITH, Washington, D. C.

The Moringuid eels are remarkable for their very elongate body disproportionately elongated abdominal cavity, and remoteness of the heart from the branchial apparatus. The family had been supposed to be peculiar to the oriental seas, but a recent discovery has directed the attention of the authors to the American eels generally and it was recognized that 3 genera previously associated with Muraenesocidae really belong to the Moringuidæ. *Stilbiscus* indeed is a synonym of the type genus, *Moringua*. A new species of the related genus *Aptalmichthys* has also been added to the American fauna.

The History of the Word Mammalia: By THEODORE GILL, Smithsonian Institution.

The word *mammalia* was first introduced by Linnaeus, in 1758, as the expression of

a concept first appreciated by him. It was formed in analogy with animal. Simple as the explanation is it has never been recognized.

C. H. EIGENMANN,
Secretary.

SCIENTIFIC BOOKS.

An Introduction to the Study of the Comparative Anatomy of Animals. By GILBERT C. BOURNE. Vol. I. London, George Bell & Sons; [New York, Macmillan]. 1900. 16mo. Pp. xvi + 269. Price, \$1.10.

It is rather difficult to form an adequate estimate of a work from its first volume. It is not easy to get the author's perspective; and then there are so many things left in doubt which the remainder of the series may straighten out. The plan of Mr. Bourne's work is peculiar. It starts out with a general chapter which deals with fundamental morphological and physiological principles, and then takes up the frog, treating first of its anatomy and then of its histology. This last subject leads up to a consideration of the cell, and this is followed by a consideration of the early history of the frog. The remainder of the book is occupied by detailed accounts of several Protozoa, Hydra and Obelia. We are promised that the second volume will deal with the Coelomate Metazoa.

A rather careful examination shows few errors, yet there are several points on which the student will need fuller information than the volume affords. Thus terms are used without explanation or definition, while here and there comparisons are made which will not be intelligible because the student has no information as to one of the subjects of comparison. While finding fault it might be well to ask why it is that many English writers persist in the use of the terms epiblast, mesoblast, and hypoblast. It is not easy to see how the work can be used in courses of comparative anatomy as usually given in America, except as a reference book for occasional use. Its wealth of detail concerning forms usually studied in the laboratory would be seized upon by many students as affording answers to the questions which they are asked and are expected to obtain from the animals themselves.

On the other hand, it contains much information which is of value to the student and which the beginner might fail to find out for himself. The discussions of individuality, alternation of generations, and sexuality are especially good.

The book is well printed and its fifty-three illustrations are well chosen and clear.

J. S. KINGSLEY.

PROFESSOR MOSSO'S LECTURES AT THE CLARK UNIVERSITY DECENTNIAL.

Two lectures were delivered by Professor Angelo Mosso at Clark University during its Decennial Celebration, in the summer of 1899, which seem to deserve wider publication than they will obtain through the volume issued and distributed by the university in commemoration of that event. This volume has been already reviewed in SCIENCE, without, however, special reference to the contents of these addresses.

The former of the lectures, of which notes are here presented, is called 'Psychic Processes and Muscular Exercise.' It would be difficult to exaggerate the importance of the ideas presented, although the campaign against present public opinion which a practical realization of some of its consequences would demand might well discourage a Pestalozzi. The logical conclusion has, however, been arrived at both by the psychologist and by the medical man, as well as by the physiologist, who is both.

One of the most important of the rising beliefs of American medical men regarding common school education is corroborated in this address by the eminent Italian. In it he sought to show "how intimately related are mental processes and movements. If we desired to make a pedagogical application," he says, "we might say that physical education and gymnastics serve not only for the development of the muscles, but for that of the brain as well."

Children should begin reading and writing only after they are nine years old, and it is becoming evident that as much time should be devoted to muscular exercise as to intellectual exercise. No absolute local separation of movement and sensibility is demonstrable. Muscular

fatigue exhibits phenomena identical with intellectual fatigue. Internal reflex phenomena seem largely to condition attention which, therefore, is not wholly within the will's control. Nerve cells have only a small power of resistance and show, on the average, every ten seconds a tendency to rest. It is probable that only part of the brain is active at a time—the various parts relieve each other. The structure of all nerve cells seems to be the same—it is only their relations which are different. The more mobile any animal's extremities the more intelligent, other things being equal, he is: the most mobile parts are those which are the most sensitive.

The other address, called by Professor Mosso 'The Mechanism of the Emotions,' adds not a little to our knowledge of the somatic aspect of emotion, dealing especially with the sensitivity of the bladder—one of the most sensitive of the viscera.

The seat of the emotions of joy and of sorrow seems to Professor Mosso to lie undoubtedly in the so-called sympathetic nervous system. In 1881 he noticed (with Dr. Pellacari) the contraction of the bladder during weak sensations. Besides those of the bladder, he has studied the movements of the stomach and intestines, including the rectum.

The bladder's movements are both active and passive, but the former are of chief interest and alone are considered here. The experiments were conducted both on dogs and on women. The instrument employed was his own plethysmograph, a very valuable hydraulic arrangement too well known to need description here. This was connected with the bladder by means of a 'female catheter.' The human subjects studied were young women in the hospitals, who, of course, volunteered their services. He recorded in the cases of both the women and the dogs the thoracic and abdominal respiration and the movements of the bladder independently. He considers that the bladder exhibits 'the most delicate reflex movements which occur in the organism.' The bladder contracted not only to very slight emotional stimuli, but also to changes in the organism instigated by problems in mental arithmetic.

In explanation, it is postulated that the blood pressure increases and the blood vessels and smooth muscular fibers contract in order to prevent the blood from collecting in the abdominal cavity, the brain requiring additional blood pressure for its additional activity—regulated by the sympathetic nervous system.

Mosso is right in denying in this lecture teleology to the reflex phenomena of strong emotions, but he is wrong in statements as to Darwin's theory, for this the latter never claimed for strong affective states. It is the excitement, and not the mode, of the emotion (pleasant or unpleasant) which, in case of the bladder, determines the loss of organic equilibrium. This is a conclusion easy to accept when we consider that one of the functions of the visceral blood vessels is to be a reservoir for blood necessarily expelled from other bodily parts.

GEORGE V. N. DEARBORN.

TUFTS COLLEGE MEDICAL SCHOOL.

SCIENTIFIC JOURNALS AND ARTICLES.

The Journal of Comparative Neurology, May, 1900. The first article, 'Observations on Sensory Nerve Fibers in Visceral Nerves, and on their Modes of terminating,' by Dr. G. Carl Huber, details observations made upon the innervation of the hollow viscera by means of methylene blue intra-vitam. This is followed by a short note by the same author on 'Sensory Nerve Terminations in the Tendons of the Extrinsic Eye-muscles of the Cat,' the organs being somewhat different from the ordinary neuro-tendinous spindles found in the other skeletal muscles. Dr. Huber and Mrs. Lydia M. DeWitt follow with a paper of 50 pages and six plates entitled 'A Contribution on the Nerve Terminations in Neuro-tendinous End-organs,' describing the structure of these sense organs as studied by the methylene-blue method in amphibia, reptiles, birds and mammals. In all cases the tendons are supplied with a special nerve end-organ consisting of several tendon fasciculi, embryonic in nature, which in birds and mammals are generally surrounded by a connective tissue capsule, while they are usually not so surrounded in reptilia, and never in amphibia. They are generally, but not always,

innervated by a single non-medullated nerve fiber, which, after repeated branching, ends in one or many tufts of non-medullated fibers, the details of whose structure vary with the different animals studied. Dr. H. H. Goddard describes and figures a new brain microtome recently made at Clark University for cutting entire human brains. F. J. Cole, of University College, Liverpool, gives a prospectus of 'A Proposed Neurological Bibliography of the Ichthyopsida.' 'The Number and Size of the Nerve Fibers Innervating the Skin and Muscles of the Thigh in the Frog,' by Elizabeth Hopkins Dunn, M.D., demonstrates that the fibers innervating the thigh are more numerous and of greater average caliber than those innervating the rest of the leg. Hence in the frog the fibers of greater diameter run the shorter course. About 8 per cent. of the fibers which innervate the thigh divide, one division running on into the lower leg. Dr. H. Heath Bawden gives 'A Digest and a Criticism of the Data upon which is based the Theory of the Amœboid Movements of the Neurone,' accompanied by a bibliography of 115 titles. The usual book notices complete the number.

THE July number (Vol. I., No. 3) of the *Transactions of the American Mathematical Society* contains the following articles: 'Wave propagation over non-uniform conductors,' by M. I. Pupin, of New York, N. Y.; 'Ueber Systeme von Differentialgleichungen denen vierfach periodische Functionen Genüge leisten,' by M. Krause, of Dresden, Germany; 'On linear criteria for the determination of the radius of convergence of a power series,' by E. B. Van Vleck, of Middletown, Conn.; 'On the existence of the Green's function for the most general simply connected plane region,' by W. F. Osgood, of Cambridge, Mass.; "'D' lines on quadrics,' by A. Pell, of Vermillion, So. Dak.; 'Sundry metric theorems concerning n lines in a plane,' by F. H. Loud, of Haverford, Pa.; 'An application of group theory to hydrodynamics,' by E. J. Wilczynski, of Berkeley, Cal.; 'Determination of an abstract simple group of order $2^7 \cdot 3^6 \cdot 5 \cdot 7$ holomorphically isomorphic with a certain orthogonal group and with a certain hyperabelian group,' by L. E. Dickson, of Austin, Tex.

DR. JOHN GUITERAS, who resigned the chair of pathology in the University of Pennsylvania to fill a similar position in the University of Havana, has established there a journal entitled *Revista de Medicina Tropical*.

DISCUSSION AND CORRESPONDENCE.

THREE FORGOTTEN NAMES FOR BIRDS.

IN *Museum Leskeanum Regnum animale quod ordine systematico disposuit atque descriptisit*, D. L. Gustavus Karsten, Vol. I., Leipzig, are proposed three names for birds which appear to have been overlooked by ornithologists, at least since 1817. The names are *Certhia longicauda*, *Trochilus maximus*, and *Pipra tricolor*, all of Karsten. Viellot (*Nouveau Dictionnaire d'Histoire Naturelle*, * * * Nouv. ed., T. VII. (1817), p. 364) refers to *Trochilus maximus* giving the proper reference to Karsten's work, but curiously enough gives Latham as the authority for the species.

While these names have not been noted in recent works it seems they do not affect any now in use in ornithologic nomenclature. This statement is made on the authority of Mr. Witmer Stone of this Academy.

From a bibliographic standpoint it would be interesting to know whether the *Museum Leskeanum Regnum Animale* (1798) consists of one or two volumes. Most bibliographers, to whom I have referred, say two volumes; but Cuvier (*Le Régne Animal*, nouv. ed., T. III. (1830) gives but one volume. In the library of the Academy of Natural Sciences of Philadelphia there is volume I. only of the work, which is divided into six classes, viz., Mammalia, Aves, Amphibia, Pisces, Insecta, Vermes, the latter including the invertebrates except the insects, from which it will appear evident that nothing remains of Animalia to be treated in another volume. The first 44 pages (classes I.-IV.) of the work are numbered in Roman, and parts V. and VI. are numbered independently, and are in Arabic (pp. 1-320). To this difference in pagination may be due the statement that the work is in two volumes. Or the fact that Classes V., Insecta (pp. 1-136), was published in advance in 1788 with a separate title-page may account for the other volume.

WILLIAM J. FOX.

ACADEMY OF NATURAL SCIENCES, PHILADELPHIA.

NOTES ON INORGANIC CHEMISTRY.

THERE has been a question frequently discussed as to the delicacy of spectroscopic reactions as compared with the sense of smell. Kirchhoff and Bunsen were able by the spectroscope to detect $1/14 \times 10^{-6}$ mg. of sodium; on the other hand, E. Fischer and Penzoldt could recognize the odor of $1/460 \times 10^{-6}$ mg. of mercaptan. It was clear, however, that the figures of Bunsen by no means represented the limit, and Professor F. Emich of the Technische Hochschule of Graz has lately devoted some time to the study of the problem. His results are published in the *Sitzungsberichte* of the Academy of Science of Vienna. His method is to use Geissler tubes with exceedingly fine capillary portion; these are filled with hydrogen under greatly diminished pressure. A slit at right angles to the capillary allows the light from a limited portion of substance to pass, the weight of which is easily calculated. The lowest pressure at which the line *H* is visible was observed and from this the calculation made. The results obtained in three observations were 1×10^{-12} mg., 7×10^{-14} mg. and 3×10^{-13} mg. It thus appears that, on the average, the quantity of hydrogen recognizable by the spectroscope is ten thousand times less than that of mercaptan by the sense of smell. Emich calls attention to the fact that if, as Hutton affirms, the ordinary hydrogen spectrum is visible only when the gas contains a trace of oxygen, the quantity of oxygen thus detected by the spectroscope becomes far more minute than the figures given for hydrogen.

THE subject of the radio-active substances in pitchblende continues to excite the interest of chemists, and much work is being done by the two Curies, Giesel, Debiegne, Becquerel, von Lengyel and others. The last number of the *Chemical News* contains a paper by Béla von Lengyel of Budapest, describing his efforts to prepare a radio-active barium synthetically. His process is to fuse together uranyl nitrate with two or three per cent. of barium nitrate, and then fuse the oxides obtained in the electric arc. The fused mass is dissolved in nitric acid, much of the barium nitrate crystallized out, and the remainder of the barium precipitated as the sulfate. The sulfate thus obtained

is found to be radio-active, and from it the chlorid and the carbonate, both also radio-active, have been obtained. Early in his paper von Lengyel says: "It is obviously clear that the question of radium being a chemical element must be answered in the negative as soon as it is found possible to transform ordinary inactive barium into the radio-active variety." In closing he says that his researches "do not nearly suffice to decide the question as to whether radium is an existing chemical element or not, but these facts render doubtful the existence of radium."

FOLLOWING this work comes that of Becquerel, described in the last *Comptes Rendus*, in which similar experiments are repeated from a different standpoint. Uranium chlorid is mixed with barium chlorid, the barium precipitated by sulfuric acid. The barium sulfate thus obtained is more or less radio-active, but the radio-activity of the uranium salt left has diminished correspondingly. These experiments show the futility of trying to determine in this manner, whether the radio-activity resides in the uranium, or is due to an independent substance which is an impurity in the uranium.

J. L. H.

THE UNIVERSITY OF BIRMINGHAM.

THE report of the Executive Committee of the Governors of the University of Birmingham, dated May 31, 1900, relative to the recent development of the work in applied science and engineering and the use of the recent gifts of Mr. Carnegie and others has been printed for distribution to friends of the university and its extended work.

On May 12, 1899, the endowment fund collected by a canvassing committee amounted to £143,000. Mr. Carnegie, through Mr. Joseph Chamberlain, offered to contribute £50,000 for a special science department when a total of £250,000 should be pledged. This condition was fulfilled within a week. On February 28, 1900, the sum had become £326,500, and at the date of the report it was £327,468.

Mr. Carnegie requested Mr. Chamberlain to send a deputation to the United States which should 'report on its return what more is necessary, to give Birmingham a first-class modern

scientific college, modeled, as I have said, after Cornell'—intending, presumably, a union of literary with scientific and professional work, as is usual in American State universities, and with a well-developed 'practical' side—not necessarily big, but perfect of its kind.' Professors Burstall, Renwick and Poynting were accordingly sent. They visited several of the principal eastern colleges of the United States and Canada. They conclude:

"We desire to express our admiration alike for the high ideal of scientific education which is the aim in American universities and for the enthusiasm in all classes which renders it possible to approach so near that ideal. Everywhere we found that the wealthier classes realize the importance of university education and encourage the universities by generous gifts and everywhere, both by teachers and by students, these gifts are being used for higher learning and research."

They "believe that the system of engineering education existing at Cornell and other institutions we have visited and the system of Mining and Metallurgy at Boston and Montreal, all with their four year courses, are admirably planned and carried out." They advise their adoption including laboratories and workshops for instruction which they found "thoroughly practical and on such scale that the knowledge acquired there by the student would be of use in his subsequent professional life."

The proposed scale of salaries is very modest—£750 for professors, £300 to £400 for assistant professors, £150 for 'demonstrators' in science and instructors in shops, and £100 and £70, respectively for minor appointments. The investment of £155,000 is proposed in buildings and equipments for the new Technical College, and anticipates an annual operative expenditure something over £10,000 with a faculty of eighteen in all grades and presumably for a student body of about 200 in all classes. A 'commercial faculty' is proposed, consisting of three officers and involving an expense of £6000 in equipment and £2200 annually in maintenance.

A four-year's course is planned, in which the differentiation between the mechanical and electrical engineers will occur at the end of the

third year and between these and the civil engineers somewhat earlier. Mathematics and pure science and the modern languages will be given in the University proper. A good general education is expected to be secured in advance of entrance into the technical courses, which are made entirely professional, as is usual in law and medicine.

R. H. THURSTON.

THE PREVENTION OF HAIL STORMS.

MR. JOHN C. COVERT, U. S. Consul at Lyons, writes to the Department of State: An effort is being made in this section of France to dissipate hail storms by firing cannon at the clouds. Fifty-two cannon, manned by 104 gunners and their chiefs, have been distributed over an area of 2500 acres of rich vine land. For the expense of the experiment, the Government appropriated 2000 francs (\$386), the departmental council 1500 francs (\$289), the National French Agricultural Society and a number of wealthy wine growers added 12,000 francs (\$2316) and furnished fourteen more cannon. The Minister of War supplied powder for 2½ cents per pound.

A high point in the vine land to be covered by the experiments was selected as the central post of observation and a signal code adopted. When a shot is heard from the central post all the cannon are fired, at first twice per minute; more slowly after the first ten shots. I translate the report of the first firing at the storm clouds this season:

The farmers of Denicé were aroused at 1.30 o'clock on the night of June 5th-6th. The storm was very severe. The artillerists, from 40 to 50 strong, fired their guns and stopped the thunder and lightning. In the neighboring communes, the people saw columns of flames rise 300 feet above the cannon when the shots were fired. At several places, women recharged the cartridges.

The wine growers are organizing to attack the hail storms in many of the great wine-growing regions of France. The two experiments thus far reported are pronounced successful. A writer in one of the wine-grower's organs says:

The results obtained from these experiments

are such that organizations will be established at once in all the places that have heretofore been ravaged by hail.

I am told that the practice of shooting at the clouds was known in France over a hundred years ago, and that it originated in Italy. It is to be more extensively carried on this year than ever before.

*BRITISH CONGRESS ON TUBERCULOSIS.**

IT has already been announced in the *British Medical Journal* that a Congress on Tuberculosis is to be held in London next year. The date of meeting has been fixed for the last week of April. H. R. H. The Prince of Wales, is the President of the Congress, and among the Vice-Presidents are the Duke of Fife, the Marquis of Dufferin, K.P., Earl Spencer, K.G., Lord James of Hereford, Lord George Hamilton, P.C., Lord Reay, G.C.S.I., Lord Lister, P.R.S., Sir John Burdon Sanderson, Sir Hermann Weber, the Presidents of the Royal Colleges of Physicians and Surgeons, the President of the Royal College of Veterinary Surgeons, the Director-General of the Medical Department of the Navy and the Chairman of the London County Council. The President of the Organizing Committee is the Earl of Derby; the Chairman, Sir William Broadbent; the Honorary Treasurers, Lord Avebury and Sir James Blyth; the Chairman of the General Purposes Committee, Professor Clifford Allbutt, and the Honorary Secretary-General, Mr. Malcolm Morris. The Prince of Wales has consented to open the Congress in person. In order to make the Congress as comprehensive as possible every colony and dependency in the Empire will be asked to send representatives, and distinguished guests will be invited from Europe, Asia and America. Authorities in these and other countries will be invited to take an active part in the work of the Congress.

It is hoped that the Congress will be able to adopt practical resolutions which will serve to indicate the measures best adapted for the suppression of tuberculosis. The work of the Congress will be divided into Sections, as follows: Section 1 (State and Municipal). Presi-

* From the *British Medical Journal*.

dent—Right Hon. Sir Herbert Maxwell, Bart., M.P. Secretaries—Dr. Bulstrode, Dr. Arthur Newsholme, Dr. James Niven. Section 2 (Pathological, including Bacteriology). President—Professor Sims Woodhead, M.D. Secretaries—Dr. Wethered, Professor Rubert Boyce, Dr. E. J. McWeeney. Section 3 (Tuberculosis in Animals). President—Sir George Brown, C.B. Secretaries—Professor Hobday, Royal Veterinary College; Messrs. Harold Sessions, F.R.C.S., Stuart Stockman (Glasgow), Frank Leigh (Bristol). Section 4 (Clinical and Therapeutic, including Climatology and Sanatoria). President—Sir R. Douglass Powell, Bart., M.D. Secretaries—Sir Hugh Beevor, Bart., M.D., Dr. Hector Mackenzie, Dr. R. W. Philip, Dr. William Calwell (Belfast). The subscription for ordinary members will be £1. As the expense of the Congress will be very considerable, donations to the Reception Fund are invited. Donations of more than one guinea will be considered as including members subscription, and will entitle the donor, whether an individual or a corporation, to all the privileges of membership.

SCIENTIFIC NOTES AND NEWS.

PROFESSOR JAMES EDWARD KEELER, the eminent astronomer, director of the Lick Observatory, died at San Francisco on August 12th, from the effects of heart disease. He was born in La Salle, Ill., on September 8, 1857.

PROFESSOR RUDOLPH VIRCHOW has been elected an honorary member of the Vienna Academy of Sciences, and Dr. Ernst Abbe, professor of meteorology and astronomy at Jena, Dr. Karl v. Zittel, professor of paleontology and geology at Munich, and Dr. Felix Klein, professor of mathematics at Göttingen, have been elected corresponding members of the same Academy.

MR. OVERTON W. PRICE, of the Division of Forestry of the U. S. Department of Agriculture, has been promoted to the position of superintendent of working-plans and assistant chief, vacant by the appointment of Mr. Henry S. Graves to the professorship of forestry in Yale University.

IN response to a recent requisition from the Bureau of American Ethnology for an assistant

ethnologist especially competent to deal with the Siouan languages, the Civil Service Commission held, on July 24th, a competitive examination for the position. Only a single candidate entered the competition—Mr. John R. Swanton, of Massachusetts, a recent student in Columbia University, where he took a special course in American linguistics under Dr. Boas; he passed the examination most satisfactorily. His immediate field of work will include reservations of the Dakota and other Siouan Indians.

THE Rolleston Prize, Oxford University, has been awarded to Gustav Mann, B.Sc., New College, for his published 'Research on the Histology of Vaccinia' and for his unpublished 'Atlas of the Anatomy of the Brain of the Frog.'

PROFESSOR WILLIAM C. STUBBS, director of the Audubon experiment station in Louisiana, has gone to Hawaii as a representative of the Agricultural Department to make a study of the sugar industry on the islands and to establish a Government experiment station there.

DR. HIDEO IKEDA of Tokio has been sent to America by the Japanese Government to study the agriculture of this country, with special reference to tobacco and cotton.

WE noted recently a movement for a memorial to the late Sir William Flower. We now learn from *Nature* that it is proposed that the memorial shall consist of a bust and a commemorative brass tablet to be placed in the Whale Room of the Natural History Museum—one of the departments in which he was most interested, and to which he devoted special care and attention. Subscriptions (which must not exceed two guineas) should be paid to Dr. P. L. Slater, treasurer of the Flower Memorial Fund, 3 Hanover Square, W.

DR. RUDOLPH HESSEL, who had charge of the propagating ponds of the U. S. Fish Commission, died at Washington on August 16th from the effects of sunstroke. He was born in Baden 75 years ago, and became connected with the U. S. Fish Commission in 1877.

PROFESSOR CHARLES SCOTT VENABLE, professor emeritus of mathematics at the University of Virginia, died at his home in Charlottesville, Va., on Aug. 11th. He was born in Prince

Edward County, Va., on April 19, 1827. He held professorships in the universities of South Carolina and Georgia and in Hampden-Sidney College. During the Civil War he was a lieutenant-colonel and aid-de-camp on the staff of General Robert E. Lee. In 1865 he was appointed professor of mathematics in the University of Virginia, and became emeritus professor five years ago.

DR. ERICH NYMANN, a Swedish naturalist from Upsala, has died at Munich on his return from a three year's expedition to the Malay Archipelago and New Guinea.

A FIELD party from the Botanical Department of the University of Chicago is making an ecological study of North Manitou Island, in the northern part of Lake Michigan. They will be at work during August and September.

MR. JAMES MOONEY, of the Bureau of American Ethnology, has recently gone to the old Cherokee country in North Carolina for the purpose of completing his studies of the traditions, games, and medical practice of the Cherokee Indians. He has an extended memoir on the creation myths and traditions of the tribe in the Nineteenth Report of the Bureau, which is now well advanced in the press; and he has, in more or less advanced preparation, two or three additional memoirs on the tribe, one or more of which he plans to complete by aid of information to be obtained during the autumn.

PROFESSOR C. E. BEECHER, of Yale University, is conducting an expedition to the Grand Canyon of the Colorado and Arizona.

IT is reported that Dr. Riggs, of the Field Columbian Museum, has discovered a nearly perfect skeleton of a dinosaur on the banks of Gunnison River, Colorado.

THE American Chemical Society will hold its next general meeting in Chicago during Christmas week. A committee has been appointed to arrange for the celebration of the 25th anniversary of the foundation of the Society which will occur on April 6, 1901.

THE British Medical Association will hold its next annual meeting at Cheltenham under the presidency of Dr. G. B. Ferguson.

THE members registered at the International Medical Congress numbered 6170, nationalities

being represented as follows: France, 2293; Russia, 805; Germany, 572; the United States, 412; Italy, 324; Great Britain, 222; Spain, 219; Belgium, 147; Austria, 141; Argentine Republic, 108; Switzerland, 101.

AT the Paris Electrical Congress, reports will be presented as follows: 'Dynamo Electric Machinery,' Professor S. P. Thompson; 'Units,' M. Hospitalier; 'Photometry,' M. Viole; 'Asynchronous Generators and Compounding of Alternators,' M. Leblanc; 'Rotary and Rectifying Converters,' M. P. Janet; 'Use of Condensers,' M. P. Boucherot; 'Tramway Current Supply,' M. Postel-Vinay; 'Electric Lamps,' M. Blondel; 'Electro-chemistry,' M. Bouilhet; 'Calcium Carbide Furnaces,' Gen. Sebert; 'Wireless Telegraphy,' M. Blondel and Capt. Ferrié.

A CIVIL SERVICE examination will be held sometime during September or October to fill the position of chemist in the U. S. Geological Survey at \$1400 per year. Candidates will be examined in theoretical and physical, inorganic, organic and analytical chemistry, assaying, elementary mineralogy and scientific French and German. The duties of the position involve especially assaying and other branches of analysis relating to geological work. The positions of physicist and assistant physicist in the U. S. Geological Survey, at \$1800 and \$600 respectively, are likewise to be filled upon examination. The date of this examination has been postponed from August 21 to September 20.

A PROSPECTIVE publication of the Bureau of American Ethnology is the extensive dictionary of the Natick (Indian) language of Massachusetts, compiled by the late James Hammond Trumbull, and for some time preserved in the original manuscript by the American Antiquarian Society, at Worcester. The vocabulary is of much interest and value as one of the two most extensive records of the language of the aborigines of New England—the other being the well known Eliot Indian Bible. It will form the initial number of a new series of bulletins to be issued by the bureau in a superior style of publication; the size, paper and binding correspond with those of the annual reports. The authority for this new series of publications

was granted during the last session of Congress at the instance of Honorable Ernest W. Roberts, of Massachusetts, for the purpose of affording suitable means of printing and distributing the large collections of rare technical ethnologic matter now in the archives of the bureau or within its reach—of which the Trumbull vocabulary is a typical example. The greater part of this vocabulary, which will include an introduction by Dr. Edward Everett Hale, is already in type.

HERR CARL MARHOLD, of Halle, announces a book by Professor Schenk under the title 'Aus meinem Universitätsleben.' It is a reply to the professors of the University at Vienna, whose memorial to the Austrian Government led to his dismissal from the university.

MR. JAMES G. CANNON, who has been engaged in the reorganization of the business of Messrs. D. Appleton & Company, has issued a statement to the effect that the plans have been perfected, and, though the Company will remain for the present in the hands of the receiver, all authors' accounts will be paid in full. This will naturally be of interest to scientific men, as Messrs. D. Appleton & Company publish a long list of scientific books. The relations of an author to a publisher who is unable to carry out his contracts is a somewhat perplexing question. Messrs. Harpers Brothers have sold certain of their publications without the consent of the authors, and it seems doubtful whether they have a legal right to do this. There should probably be in America, as there is in England, a society of authors which could give advice, and, if necessary, take legal proceedings. Perhaps a committee of the American Association for the Advancement of Science could perform this function for scientific men.

A DECISION has been rendered by the British House of Lords which somewhat concerns scientific teachers and lecturers, and has probably never been before the Courts in the United States. Certain speeches of Lord Roseberry's were reported verbatim in the London *Times* and these were republished without the permission of the proprietors of the newspaper in question. Suit was brought to restrain the publication, and this was granted in the first

Court. The decision was reversed in the Court of Appeal, but has now been re-affirmed by the highest court. This court holds that the verbatim reporter of a speech is the 'author' in the meaning of the copyright act. Perhaps the lectures given to a class of students or a paper read before a scientific society are not made public. But if so, according to this decision, they could be reported and published by anyone, and the report copyrighted, so that not even the author himself could use it.

Nature states that the Botanical Museum of Florence has recently received a donation of considerable interest in connection with the history of botany in Italy, viz., the collections made by Micheli, by Bruno Tozzi, and by G. Targioni-Tozzetti in the 18th century, including the type-specimens of species named by these and other eminent botanists. The donation includes also Micheli's and Targioni-Tozzetti's collections of seaweeds.

THE Commercial Cable Company's new cable from the Azores to New York, via Novia Scotia, has been successfully laid by the cable steamers *Faraday* and *Silvertown* and is now completed and in working order. This line, which forms the Commercial Company's fourth Atlantic cable, connects at the Azores with the system of the Europe and Azores Telegraph Company and was opened for business on August 1st.

THE 'Two-Penny Tube,' as the Central Electric Underground System of London has been named, as constructed and equipped by American contractors, is making a great impression with its bright, porcelain-lined, electric-lighted, cleanly stations, brightly illuminated carriages and smooth and rapid service. The indications are that suburban transportation in Great Britain and on the Continent will be revolutionized by American methods.

WE take from *Nature* the following items: Mr. Leonard S. Loat, who is investigating the fishes of Egypt for the British Museum and the Egyptian Government, was last heard of at Korti, where he reports (on May 18th) a hot wind and a temperature of 115° in the shade. He had sent home upwards of 2200 specimens of Nile-fishes to the Natural History Museum, and as soon as the river had risen sufficiently would

proceed to Senaar and Khartoum. Mr. J. S. Budgett, who is engaged in collecting fishes on the River Gambia, dates his last letters (June 22d) McCarthy's Island in the interior. There had been a disturbance in the colony, and one of the Commissioners and a party of police were believed to have lost their lives; but this had not affected Mr. Budgett's operations, and he had a large number of Polypteri and Protopteri in floating cages in the river. He was in good health, and expected to be home in September.

AT the recent annual meeting of the Victoria Institute, the address, 'On our Coal Reserves at the Close of the Nineteenth Century,' was given by Professor Edward Hall, F.R.S. The author had selected this subject for the annual address, because public attention had recently been directed to the question of coal reserves, owing chiefly to the increased price of coal and to the unprecedented output of this mineral from British mines, amounting in 1899 to 220,085,000 tons, being about 18,000,000 tons over that of the previous year. Referring to the Royal Coal Commission of 1866, presided over by the late Duke of Argyll, the author stated that the production had doubled since the Report of that Commission was issued in 1870—a result scarcely anticipated by the Commissioners—and the public were inquiring 'for how long a period our coal reserves would be able to bear the increasing drain.' The author advocated the imposition of an export duty on coal shipped to Continental states, which were taking from us about 40,000,000 tons annually, so as to form a fund towards the relief of increasing taxation, and he concluded by the proposal for a new Commission on coal resources, showing the subjects which would require investigation.

UNIVERSITY AND EDUCATIONAL NEWS.

THREE scholarships in music have been endowed in Yale University by Mr. Morris F. Steinert. Mr. Steinert has already endowed four scholarships in music at this institution, and has given it an important collection of musical instruments.

A GIFT of £1000 has been received by the University of London from the children of the

late Mr. William Lindley, in remembrance of their father.

THE following additions have been made to the faculty of the engineering departments of the Iowa State College at Ames, Iowa: H. J. Burt (University of Illinois), assistant professor of civil engineering; Dr. Samphear (Cornell University), assistant professor of electrical engineering; L. J. Young (State College, Pa.), instructor in mining engineering, and I. A. Williams (Iowa State College and University of Ohio), instructor in ceramics.

THE Montana School of Mines, at Butte, will begin its college year on the second Tuesday of September. A serious lack of funds has delayed the successful opening of the school for some time, but it is now hoped that the institution can open and offer the courses of study which its organizers have carefully arranged. The present faculty includes Nathan R. Leonard, acting president, and professor of mathematics, recently of the State University of Iowa; William King, professor of chemistry and metallurgy, a graduate of the Western Reserve University, and for sixteen years instructor in chemistry in the Case School of Applied Sciences in Cleveland and for two years in the College of Montana at Deer Lodge; and Dr. Chas. H. Bowman, professor of mechanics and mining engineering.

DR. W. D. SCOTT, Ph.D. (Leipzig), has been appointed to a newly created instructorship in psychology and pedagogy in Northwestern University.

DR. NAGEL, docent in physiology in the University at Freiburg, i. B., has been promoted to an assistant professorship, and Dr. Ernst Weinschenk to an assistant professorship of petrography in the University of Munich.

DR. KARL BOEHM has qualified as docent in mathematics in the University of Heidelberg, and Dr. P. Rabe as docent in chemistry in the University at Jena.

DR. LE DANTEC, professor in the medical faculty of Bordeaux, has been appointed to give a course of instruction in tropical diseases. In Holland the teaching of tropical medicine has recently been inaugurated by Dr. J. H. Kohlbrugge, docent in the University of Utrecht.